

The AMSAT[®] Journal

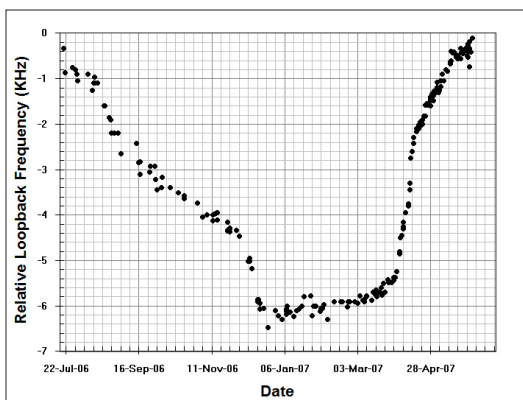


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Volume 30, Number 3

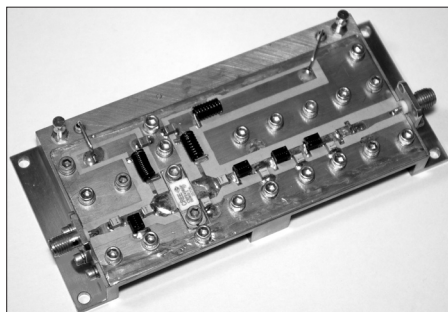
May/June 2007



Hello up there! May we check your temperature?



. . . - . -



Parts is parts? This one's for Eagle!

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A codicil in your will, naming The Radio Amateur Satellite Corporation as a beneficiary will help insure the continuance of the Amateur Radio Satellite program.

Call the AMSAT-NA office at 301-589-6062 for questions on any or all of these ways you can help build new and exciting satellites.

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AMSAT Announcements

Call for Papers – AMSAT-UK Colloquium – July 2007

This is the first call for speakers for the 22nd AMSAT-UK Colloquium, which will be held at Surrey University, Guildford, Surrey, U.K., from Friday, 20 July to Sunday, 22 July 2007. AMSAT-UK invites speakers, about Amateur Radio space and associated activities, for this event. They are also invited to submit papers for the "Proceedings" document that will be published at the same time but printed papers are not mandatory. We normally prefer authors to present talks themselves rather than having someone else give them in the authors' absence. We also welcome "unpresented" papers for the Proceedings document.

Offers of talks should be submitted as soon as possible. The final date for full documents to be received is June 2007 so that the "Proceedings" document can be available to participants. Submissions should be sent ***ONLY*** to G4DPZ, via the following routes: e-mail: dave@g4dpz.me.uk. Terrestrial mail: To QTH at www.qrz.com

AMSAT-UK also invites anyone with requests for Program Topics to submit them as soon as possible to G4DPZ. Invitations for any papers on specific subjects will be included in the future call. Likewise if anyone knows of a good speaker, please send contact and other information to G4DPZ. Additionally, AMSAT-UK will be running sessions specifically for beginners to amateur satellite operating on the Friday and Saturday afternoons.

Details of the colloquium can be found at: <http://www.uk.amsat.org> 

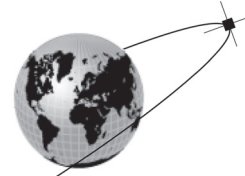
AMSAT's Mission

AMSAT is a non-profit volunteer organization which designs, builds and operates experimental satellites and promotes space education. We work in partnership with government, industry, educational institutions and fellow Amateur Radio societies. We encourage technical and scientific innovation, and promote the training and development of skilled satellite and ground system designers and operators.

AMSAT's Vision

Our Vision is to deploy high earth orbit satellite systems that offer daily coverage by 2009 and continuous coverage by 2012. AMSAT will continue active participation in human space missions and support a stream of LEO satellites developed in cooperation with the educational community and other amateur satellite groups.





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The AMSAT Journal staff is always interested in article submissions. Whenever possible, submissions should be sent via e-mail to journal@amsat.org using plain text or word processor files; photos or figures in TIF, GIF or JPEG formats. AMSAT-NA reserves the right to select material for *The AMSAT Journal* based on suitability of content and space considerations. The editors of this publication are volunteers giving freely of their talents, time and efforts to produce *The AMSAT Journal*.

AMSAT Needs You!

I usually put this section at the end of my column but this month I want you to think about this as you read over the rest of my report.

AMSAT needs your support to achieve our goals. We need a continuing commitment by our membership to fund the projects that will ensure a future for ham radio in space. We also need more of our membership to step forward and volunteer some of their time to help AMSAT.

There are many positions that need filling. You can mentor others by joining the Field Operations Team. You can contribute time as a legal advisor or marketing director. AMSAT needs another Web site developer and we need embedded software developers, PCB schematic capture and PCB layout designers. And this is only a sampling of the jobs available for volunteers.

Let me focus on two openings. I need a marketing director. At the next board meeting I plan to ask the board to split the Marketing and User Services position into two positions. To paraphrase Wikipedia's description of "marketing" the new marketing director will need to address the two major factors of marketing; the recruitment of new members (acquisition) and the retention and expansion of relationships with existing members (base management) [1]. There are a wide range of ways to accomplish these goals and I am open to working with the new director to establish his or her own job description to that end.

Another position AMSAT needs filled is that of Web site developer. Emily Clarke, N1DID, has done a fantastic job. For three years Emily has carried this heavy load nearly alone and done a wonderful job. Now we need to maintain and improve the Web site and the AMSAT store, which is located on a different server, while Emily continues development work on other advanced AMSAT projects. A successful candidate for this position would live and breathe things like HTML, PHP, server side includes and SQL. C, C++ and Perl programming would also be advantageous. All of this on both Linux and FreeBSD host environments, as AMSAT has no Windows servers.

Please call Martha in the AMSAT office at (301) 589-6062 or visit the AMSAT Web Store to make your donation to keep us going. Donations of \$120.00 or more qualify for President's Club status.

For information on setting up a hamfest AMSAT booth or giving presentations at local ham clubs contact Martha at the AMSAT office (301) 589-6062 or your AMSAT Field Operations director, Gould Smith, WA4SXM@amsat.org.

Dayton Hamvention

The 2007 Dayton Hamvention was held in May. It is one of the two main events of the year for AMSAT and it was a great event. The weather was the best in recent memory, cool and dry. The first annual joint AMSAT/TAPR banquet was conducted at the Air Force Museum and was attended by a record turnout of over 300 people. The price of the dinner included admission to the museum so it was a great bargain. It was great to meet with many AMSAT members, many of whom I only see once or twice a year.

2007 AMSAT Space Symposium and Annual Meeting

The 2007 AMSAT Space Symposium and Annual Meeting is to be held October 25-28, 2007 in Pittsburgh, Pennsylvania. The first call for papers for the 2007 Symposium has gone out and meeting details will soon be posted on the AMSAT Web site. I recommend that you block out the dates on your calendars and look at early deals on airfare as this meeting is coming up sooner than you think.

Please consider authoring a paper for this year's symposium. We request a one-page abstract immediately. Camera-ready copy on paper or in electronic form will be due by September 1, 2007 for inclusion in the printed symposium proceedings. Abstracts and papers should be sent by e-mail to Daniel Schultz, N8FGV, n8fgv@amsat.org.

Phase 3E Satellite

Work continues on the payloads and control systems for P3E. I met Howard Long, G6LVB, at Dayton. He has been working on the Mode B (U/V) SDX transponder and the UHF receiver front end for the SDX.

The flight-ready CAN-Do Satellite Bus modules have been shipped to Germany. An Internal Housekeeping Unit (IHU-3) has been duplicated in Germany by Hartmut Paesler, DL1YDD, from drawings posted on

Apogee View continues on page 30 ...



Metal or Plastic? (Boom that is...)

by Mark Spencer, WA8SME, mspencer@arrl.org

ARRL Education and Technology Program Coordinator

I had the opportunity in a previous *Journal* to share with you a Signal Fading Study Technique [1] that I developed to take a closer look at signal fading between the satellites and a ground station. I also had a secondary purpose for that study, to see if I could quantifiably evaluate my station performance to make better judgments on improvements to my antenna system. The technique was based on some homegrown software [2] that reads the rig's (IC-910) S-meter during a pass and dumps the time-stamped data to Excel for exploitation and analysis. The technique worked pretty well and provided some good insights that allowed me to at least convince myself how to prioritize my antenna projects.

I was using M² antennas for up and down links mounted on a metal cross boom made from scrap fencing material. In the antenna documentation, M² states, "The [antenna] is a circular polarized antenna and creates a field in all planes or polarities. Performance DETERIORATES SIGNIFICANTLY if it is mounted on a metal (conductive) mast or crossboom." [3] I suspected that I had seen the effects of that predicted "deteriorated polarity pattern" because of my metal-cross boom during my signal fading study, but I wanted to know just how much of a problem it was. Seizing the opportunity during a visit to M² and their annual BBQ (and a severe moment of weakness on the part of my XYL), I picked up an 11-foot fiberglass cross boom for my antenna system. Having a price tag of \$186 (list), I needed to convince myself that the price was worth the added performance, if any, and I wanted to validate the intuitively obvious disclaimer in the M² documentation. The Signal Fading Study Technique was again used in this effort.

Procedure

I had collected data on a number of AO-51 and AO-27 passes during the previous study. I had also done a pretty comprehensive SWR evaluation of the antennas. My metal

boom was 11-feet, the same length as the replacement fiberglass boom, therefore it was easy to make a quick swap and have the only change in the antenna installation be the fiberglass boom. So my previous data was usable.

During this study I did:

1. A subjective anecdotal (gut) evaluation of changes in signal strength and de-sensing.
2. The same SWR evaluation of the antennas on the fiberglass boom.
3. Collected pass data as was done during the previous study.
4. Some additional statistical analysis to quantify any differences between the two booms.

I wanted to see if there were any noticeable changes in signal strength, in de-sensing during cross-band duplex operation, in the antenna SWR and in signal fading. Intuitively, there was no doubt that the fiberglass boom should improve the circularity of the antennas, but what was unknown was how much the improvement in circularity would improve the satellite reception.

Anecdotal Observations

I immediately noticed during the first satellite pass that the signal strength appeared to be about two S-units better than before. This again was observed during the next and subsequent passes. I also noticed a dramatic reduction in de-sensing while transmitting. In fact it was only detectable at the higher power levels. So things were looking pretty good, but I was also cautiously optimistic. Remember I had just spent \$186 on an 11-foot section of plastic pipe (and admittedly, the XYL wasn't all that impressed).

Empirical Observations, SWR

The next test was to evaluate the SWR. I used a Bird 43 wattmeter with the appropriate slugs. The two SWR curves are shown in Figures 1 and 2. The metal boom related graphs are depicted with dashed lines. The

fiberglass boom related graphs are depicted with the solid lines. The results of my SWR evaluation were a bit unexpected. The overall SWR of both antennas is very good so I am not complaining, but there appeared to be no significant change in the SWR of the 2 meter antenna, and a slight degradation in the SWR of the 70 cm antenna.

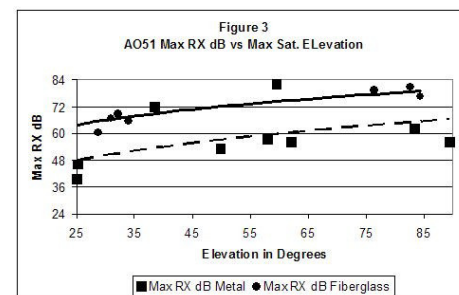
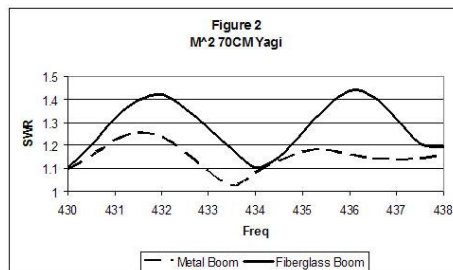
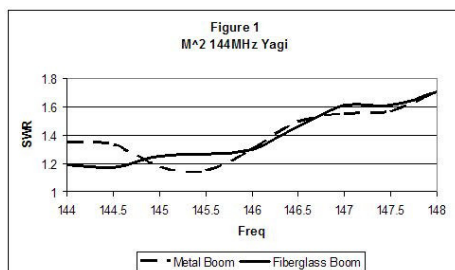
Signal Strength

To evaluate the change in received signal strength, I compared the measured signal strength at the maximum elevation of the satellite for a number of passes for each satellite, AO51 and AO27. The results are depicted in Figures 3 and 4 and again the metal boom data is shown by the dashed line and the fiberglass boom data is shown by the solid line. I used the scatter plot graphing function and trend-line analysis function of Excel to do a curve fit of the data. There appears to be about a 12 dB increase in signal strength using the fiberglass boom over the metal boom. This is consistent with my anecdotal observations.

Signal Fading

I came to the conclusion during the Signal Fading Study that the apparent fading experienced during a pass could be mitigated somewhat by using circularly polarized antennas. Circularly polarized antennas can provide the better opportunity to capture the most signal from a changing polarized signal coming down from the satellite. If I assume that the metal-cross boom distorts the circularity of the antenna polarization, then I would expect deeper fading because the elliptical polarization pattern would not be as effective in capturing as much signal from the meandering polarized signal. On the other hand, the fiberglass-cross boom would have minimal effect on the antenna circularity and therefore the fading should not be as deep.

To test this theory, I collected pass data with the fiberglass boom as I had done previously



with the metal boom. The data consisted of signal strength as indicated by the receiver S-meter and the calculated path loss due to the distance traveled from the satellite to the ground station. The path loss is the theoretical “best case” signal strength that can be expected. Any deviation from the “best case” is the result of things that we can attempt to mitigate through station and antenna design.

To then compare the two sets of data (measured signal strength and expected signal strength, i.e., path loss), I used the correlation statistical analysis function of Excel. The correlation coefficient is a measure of the extent to which two measurements (data sets) “vary together.” The two data sets do not need to be of the same scale, or even measure the same thing. For instance, there can be a correlation between height and weight of a group of individuals. In this case, I am using the correlation analysis tool to examine each pair of data points (signal strength vs. path loss) to determine if the two data sets move together. If there is perfect correlation (they go up or go down together at the same scaled relative rates), then the correlation is equal to 1. If there is perfect negative correlation (one goes up while the other goes down, but at the same relative rates, just different directions) then the correlation is equal to -1. If there is absolutely no connection between the measurements, then the correlation is 0 (zero). So the bottom line is, the closer the correlation is to 1, the more closely connected the data sets are. (That is your statistics lesson for today.)

Let’s take a look at AO-51 first. The graphic of a typical AO-51 pass is shown in Figure 5. The smooth curve is the calculated path loss (from a NOVA generated list for the pass). The erratic curve is the measured signal strength. The magnitude of the deviations from a smooth curve for the measured signal strength indicates the level or amount of fading that occurred. Using the correlation function to compare the path loss

curve to the measured signal strength over a number of passes while using the metal boom resulted in an average correlation coefficient of 0.8643. This is pretty good (remember a perfect correlation would be 1). This level of correlation should be expected because the polarization of AO-51 is RHCP (in this mode), which matches the polarization of the antenna. In comparison, the same evaluation was made of AO-51 passes using the fiberglass boom. The average correlation coefficient was 0.8637 - virtually no difference! (This was confirmed using the statistical t test that indicated there was no significant statistical difference.) At first I was disappointed that there wasn’t a difference, but then I considered that since the correlation was pretty good to begin with, any improvement with the fiberglass boom would be minimal at best.

Now let’s turn to AO-27. The graphic of a typical AO-27 pass is shown in Figure 6. The measured signal strength plot is definitely different than that generated by AO-51. The depth of the fades is greater and there is some periodicity in the fades, probably due to the satellite’s rotation. Remember AO-27 uses a vertically polarized antenna, so deeper fades should be anticipated - but how bad? Analyzing the AO-27 pass data with the correlation function revealed that the average correlation coefficient for the metal boom was 0.3849, showing less than optimal correlation (this is confirmed just by looking at the graph and the depth of the fades). In comparison, the average correlation coefficient when using the fiberglass boom was 0.5300! Now this was an improvement. This improvement was verified by using the t test, which showed that the difference between the data sets was a statistically significant improvement. In applying a little common sense here, there was more room for improvement to begin with, and the improved circularity of the antenna pattern allows the antenna to more efficiently capture the signal as it changes and shifts its polarity. If I had to put a number

to the amount of improvement, I’d be comfortable in stating a 25% improvement in signal quality.

Education Slant

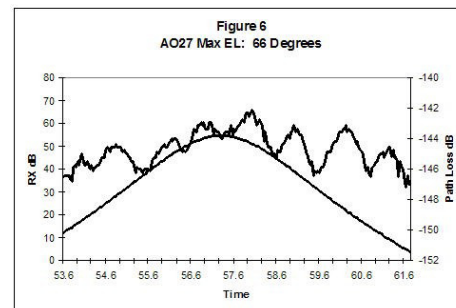
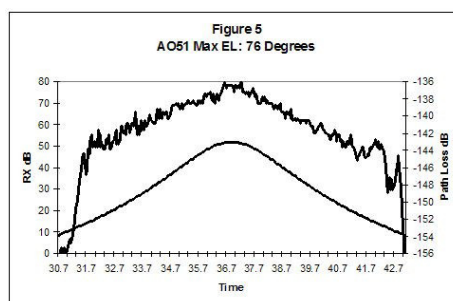
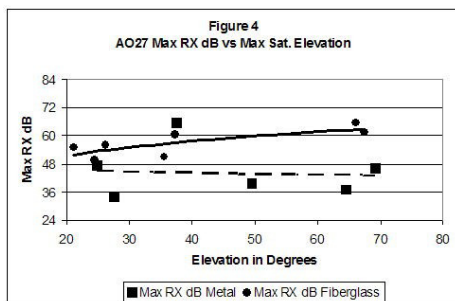
For the educators among the readers, you might consider an adaptation of this activity for your classroom. This activity would be good for instruction in problem solving, using the scientific method, hypothesis development and testing, data collection, data manipulation and analysis and statistical analysis. For readers with youngsters, your student might consider an adaptation of this activity for a science fair project. If well done and well presented, a project similar to this would blow the competition away.

Conclusion

So what did I find when I compared the metal boom to the fiberglass boom? I summarize my observations in Table 1. There was marginal effect on the antenna SWR; however, it was good to begin with. There was (subjectively) improvement in de-sensing. There was about 12 dB increase in signal strength. There was no real improvement in signal fading with AO-51, but again, it was pretty good to begin with. There was significant improvement in signal fading with AO-27. So what’s the bottom line? Is it worth using a non-conductive boom? I guess it all depends on what your definition of “is” - is...oops, I mean “significant.” I’d say the improvement in received signal strength justifies the fiberglass boom, but the improvement in signal stability, particularly for the linearly polarized satellites, is a good side benefit.

So have I been able to convince my XYL of the benefits of a fiberglass boom?...yah, right, I suspect you know the answer to that.

continued on page 15 ...



Switching Four Polarizations on a 70 cm Crossed Yagi (Part 2)

by Domenico Marini, i8CVS, domenico.i8cvs@tin.it

Construction

This polarization switcher was described theoretically in Part 1 of this article published in a previous issue of *The AMSAT Journal*. Its efficiency depends on the accuracy used when cutting and directly soldering all of the coax cables to the relay ports as shown in Photos 1 and 2. The coax cables and delay lines are shown in the schematic diagram in Figure 1. Before cutting the cables carefully read the following construction tips:

Feed lines X1 and X2 are made with RG-303 coax cable, with $Z_0 = 50$ ohms, 4.3 mm OD, Teflon insulated and 0.96 mm OD, silver-coated Copperweld center conductor.

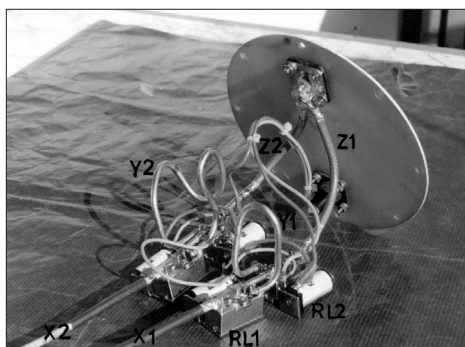


Photo 1. The complete Switcher before being fitted into the protection tube in Photo 8. The longer loop of UT141 is the delay line Y2 and the shorter loop is the delay line Y1.

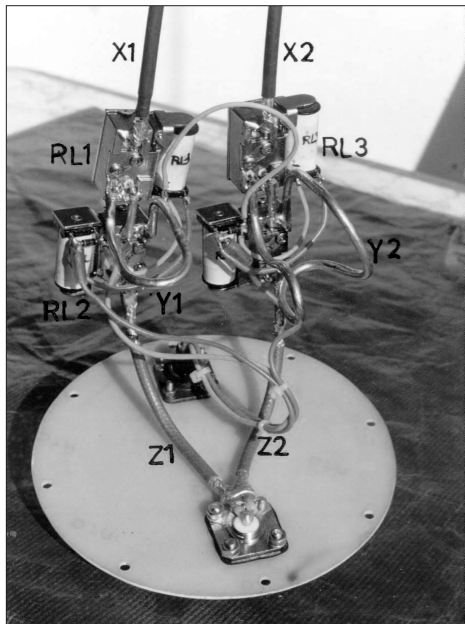


Photo 2. The complete switcher as wired following the schematic diagram in Figure 1.

X1 = 542.0 mm long, reference length

X2 = 661.6 mm long, equivalent to $X1 + 1/4 \lambda_c$ at 435.0 MHz

Matching lines Z1 and Z2 are made with RG-302 coax cable, $Z_0 = 75$ ohms, 5.2 mm OD, Teflon insulated and 0.56 mm OD, silver-coated Copperweld center conductor.

Z1 and Z2 = 119.65 mm long, equivalent to $1/4 \lambda_c$ at 435.0 MHz

Joining cable Y with delay lines Y1 and Y2 is accomplished using semi-rigid tinned copper tube coax cable (type RG402/UT141), $Z_0 = 50$ ohm, 3.58 mm OD, Teflon insulated and 0.91 mm OD silver covered copper clad steel center conductor.

Y = 18.5 mm long, reference length

Y1 = 138.15 mm long, equivalent to $1/4 \lambda_c + Y$

Y2 = 257.81 mm long, equivalent to $1/2 \lambda_c + Y$

The coax relay is a TOHTSU model CX 120 P (four are needed; see Photo-3) Type: SPDT Coax Relay

Connectors:

circuit board mount

Maximum frequency: 1500 MHz

Maximum power: 150 watts at 500 MHz

Insertion loss: 0.2dB at 500 MHz

Impedance: 50 ohm

SWR: 1.2:1 nominal at 500 MHz

Isolation: 34 dB at 500 MHz

Coil voltage: 11-15 VDC

Coil current: 80 mA at 12 VDC

Switch time: 20 msec nominal

Dimensions: 1.4"L, 1.4"W, 0.7"H

Weight: 2.5 oz

Construction Tips

When cutting the $1/4 \lambda_c$ and $1/2 \lambda_c$ coax lines, the golden rule is "When in doubt, cut it short". Do not allow extra length for what you may think may be part of the line length – you will almost invariably be wrong.

Of course, you must consider the velocity factor V_f of the cable. For RG-303, RG-302 and UT141 this is a very constant and stable

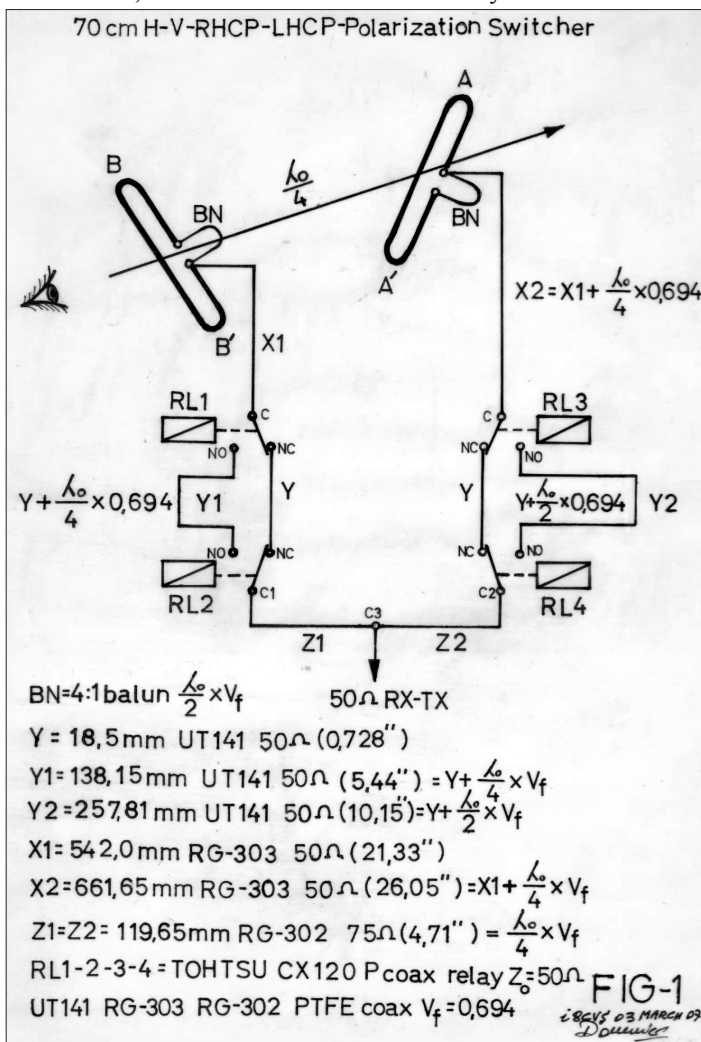


Figure 1. The schematic diagram of the four polarization switcher for a 70 cm crossed Yagi (see Part 1 for details).

value of $V_f = 0.694$ so that $\lambda_c = \lambda_0 \times 0.694$ where λ_0 is the free space wavelength.

For UT141, cut the end of the coax flush and only 4.0 mm longer than necessary at each end using a small pipe-cutter 3 to 16 mm O.D (1/8" to 5/8" OD).

Working Example

The delay line Y2, as soldered in place to the relay ports, is calculated to be 257.81 mm long. So using the pipe-cutter on a straight piece of UT141, mark two thin, circular tracks on it for reference at a length of 257.8 mm. Using the pipe cutter, mark two additional deep circular tracks 4.0 mm apart, one track at each end and cut a full piece of coax 265.8 mm long. Using a small penknife or a pincers, remove 4.0 mm of the outer

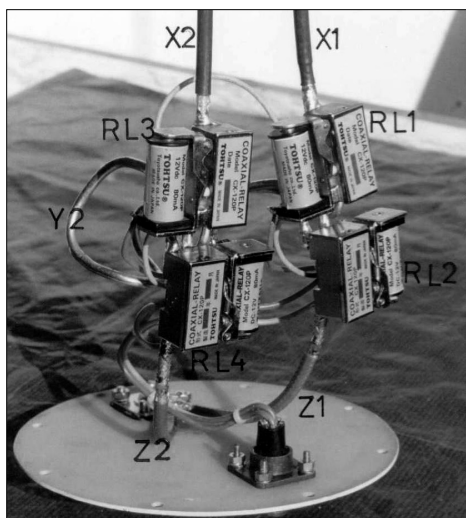


Photo 3. The coax relays, RL1-2-3-4, are Tohtsu model CX 120 P as seen from their front cover.

copper tube at each end bending the outer tube up and down slowly over the previously made thin reference mark.

Using a razor blade or an X-ACTO knife cut flush and remove 4 mm of Teflon insulating material from over the inner conductor at each end. Be careful to not cut too much toward the inner conductor or you will score it and it will break while bending it 90° to fit over the relay stud.

Now, Y2 can be shaped by hand into any form needed. After soldering both 4 mm ends in place the effective length of Y2 will be very close to 257.8 mm because the additional length of both 4 mm inner conductors that are exposed beyond the shield conductors and the relay stud lengths both become part of the length of the line. (See Photo 4)

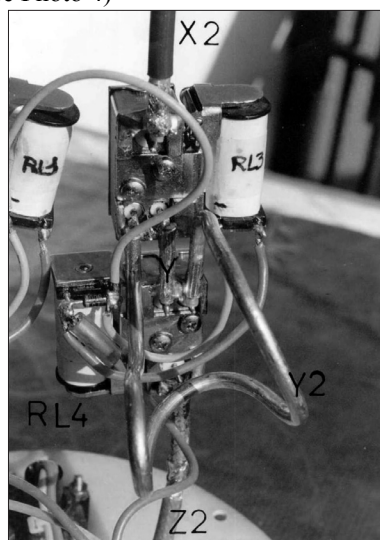


Photo 4. Detail of the branch X2 including the joining line Y connected between the NC contacts of relays RL3 and RL4. The larger loop of coax UT141 is the delay line Y2.

The feed lines X1 and X2 are made using RG-303 and they are respectively 542.0 mm and 661.65 mm long. By the way, X1 can be cut to any convenient length, but it is mandatory that X2 be $1/4\lambda_c$ electrical wavelength longer, e.g., 119.65 mm longer than X1.

Focus your attention at the end of X1 and X2, which is connected to the driven elements and note that no coax connectors are used at the feed points on folded dipoles. This is shown in Photo 5. A solder stud for the inner conductor and a copper clamp for the braid are used as KLM did in the original cables.

The best method to precisely make X2 longer by 119.65 mm than X1 is to cut two pieces of RG-303 both 662.0 mm long and create the same connection arrangement shown in Photo 5. Try to solder both studs and copper clamps as symmetrically as possible over the cables and then cut away exactly 119.65 mm of coax from the other end of X1.

To solder coax cables correctly on the relay ports, a powerful soldering iron ranging from 100 to 150 watts is necessary to compensate for the drop of temperature due to relay metallic mass. The best flux cored solder wire to be used is the alloy 62Sn/36Pb/2Ag from Alpha Metals Inc.

The coax relay has three posts originally designed to be fitted into the PCB for ground purposes and they must be completely pre-tinned, including the entire surface all around the point from which the posts exit the metal as shown in Photo 6.

Soldering the relay body is possible because the metal is plated with a conductive metal similar to that used on SMA aluminum connectors. The finished surface is compatible with the usual soldering processes.

Soldering a big metallic mass requires that the relay body be maintained at high temperature. This is why a big soldering iron of the type used to solder copper bars over DC motor collectors is necessary. By the way, the body of this coax relay can withstand soldering temperatures for several minutes since all contacts and moving parts inside of it are Teflon insulated.

The best soldering procedure on the workbench is to grip the relay in a small vice. Keep it protected from the vice jaws using two pieces of wood. This will prevent heat loss in the vise. The wood will burn slightly while soldering. Don't forget to remove the relay cover before gripping the delicate relay in the vice jaws. The braid of the outer

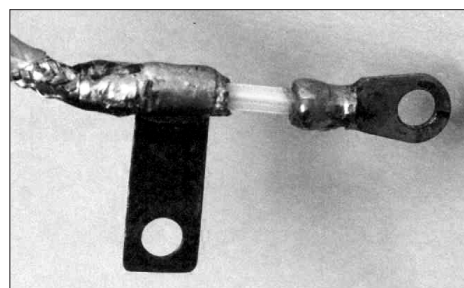


Photo 5. Detail of the stud for the inner conductor and for the copper clamp over the braid of coax cable RG-303 at the end of X1 and X2 to be connected to folded dipoles B-B' and A-A'.

copper tube of the coax must be pre-tinned before being soldered in place.

Do not scratch or remove the conductive coating from the relay body or apply the soldering iron to it.

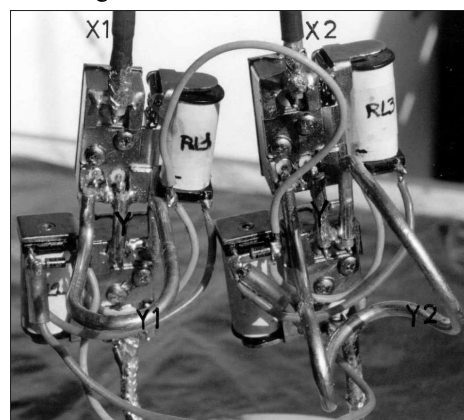


Photo 6. Close view of the soldering technique between coax cable UT141 and the relay ports.

As soon as the solder is completely melted over the surface all around the ground post, the coax braid can then be positioned over it in a way to fit the center conductor in direction of the contact stud. (See Photo 7.)

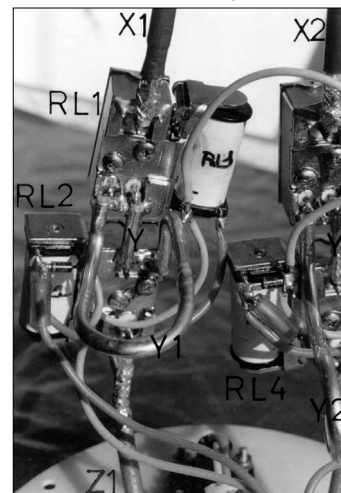


Photo 7. Detail of branch X1 including the joining line Y connected between the NC contacts of relays RL1 and RL2. The short loop of coax UT141 is the delay line Y1.

Start the job soldering by first the joining line Y between the two relays RL1 and RL2 and then proceed with soldering the delay line Y1 while the metal is still hot. Then complete lines X1 and Z1.

Don't worry about the time you need to get a good solder joint between the coax braid and relay metal body because the Teflon inside the coax cable and relays will withstand high temperatures for a long time during soldering.

When all the soldering between the coax braids and relays is completed, then the center conductors can be soldered to the contact lugs and the coils of relays can be wired following the schematic diagram in Figure 6 (See this also in Part 1.) The entire polarization switcher is enclosed in to a homemade lightweight cylinder made from a piece of plastic pipe that is 120 mm OD and 160 mm long. The pipe I used was originally used for irrigation. Plastic is much better than metal because the cylinder must be located in close proximity to the folded dipoles and reflectors. One end of the tube is closed using a plastic foil sealed with two part epoxy adhesive and carries two cable glands to feed through X1 and X2 (See Photo 8A.)

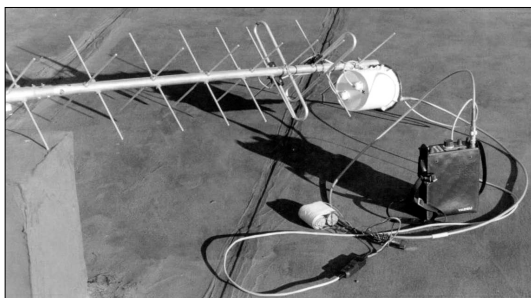


Photo 8A. The polarization switcher enclosed in a home brew cylinder made from a piece of plastic pipe 120 mm OD and 160 mm long. The flanged side carries an N female connector and a 3 pole IPT02A- 8-3P male connector to switch the 12 volt DC power supply for the relay coils.

The other end of the tube is flanged to a plastic foil using eight stainless steel 4 MA bolts with a rubber gasket for water protection (Photo 8B) and carries an N female connector plus a three pole IPT02A- 8-3P male connector to switch the 12 volt DC power supply to the relay coils.

As shown in Photo 9 before enclosing the switcher into the plastic cylinder, a foil

of insulating material (Mylar) is placed between each relay to prevent any possible accidental contact when in operation. When mounted over the boom the bottom side of the plastic tube must be drilled 4 mm in diameter to drain out the humidity and prevent condensation. The weight of the complete switcher is 800 grams while the weight of the original switcher CS-2 with its aluminum case is just 500 grams. This implies the need to balance the position of the U-bolts & cradles over the boom mounting the clamp for the mast backwards by about 240 mm with reference to the original position, i.e., mid way between the vertical director D7 and the horizontal director D7 as shown in Photo 10.

The new clamp position over the boom (Photo 10) places the mast in a null and far away from the unwanted multiples of $1/2\lambda_0$ from the driven elements as strongly recommended in Reference 4.

Note that the original 7 mm holes that accept the U-bolts & cradles over the boom are oriented to mount the elements crossed over the mast. But we need an X configuration for the elements. To avoid drilling new

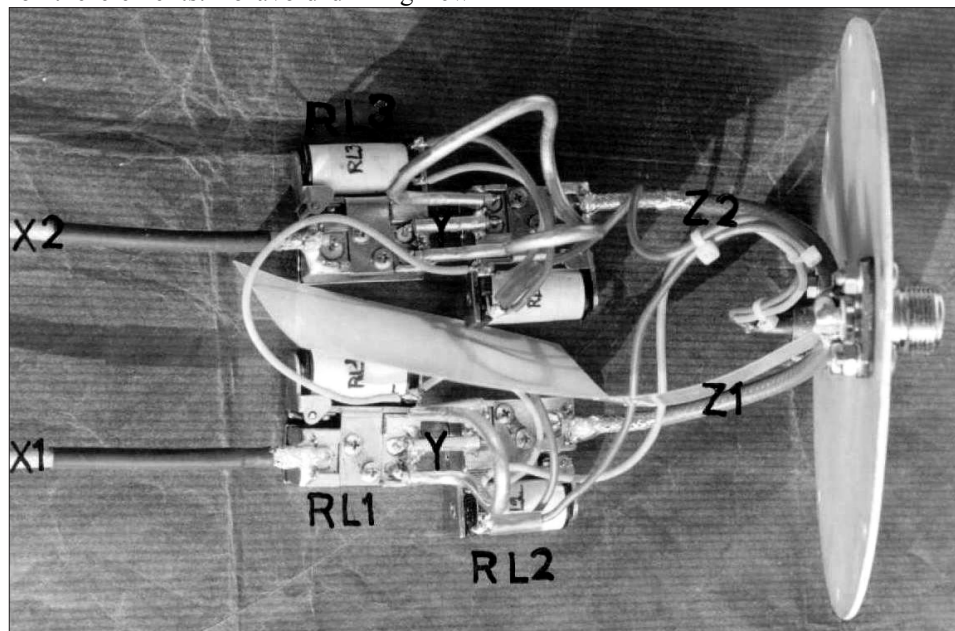


Photo 9. Before enclosing the switcher in the plastic cylinder, a sheet of insulating material (Mylar) has been placed between each relay to prevent any possible accidental contact when in operation.

holes in the boom, a mast mount 4" x 6" formed aluminum plate recovered from an old antenna has been used. This plate (Photo 10a) can be oriented to any angle without needing to drill any additional holes in the boom.

Measurement and Test

The switcher has been tested in the lab using

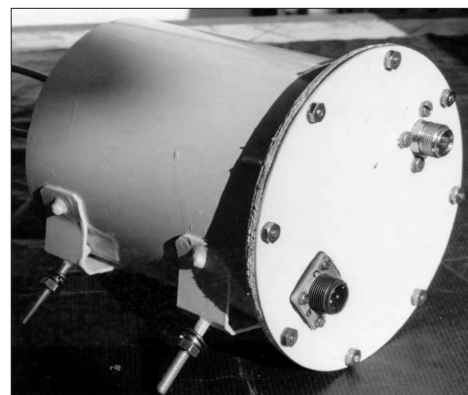


Photo 8B. The closed end of the plastic cylinder carries two cable glands to feed through the lines X1 and X2. The antenna as tested with a 50-ohm coax cable and a shielded 12 VDC switching line coming off the rear of the boom going to an FT-790R and a polarization switch visible on the ground. a precise VSWR reflectometer with an HP-8555A spectrum analyzer, an HP-8444A tracking generator and an HP-8640B signal generator.

The dipoles A-A' and B-B' were replaced with 50-ohm chip resistors directly soldered as a load at the end of X1 and X2 keeping as short as possible the soldering distance between the braid and center conductor.

The general rule to minimize stray reactance is: "If you can remove the component and use it again, the leads are too long."

With both 50-ohm resistive loads connected in place the return loss was measured at 435.0 MHz. This is shown in Table 1.

Note that when both dipoles are matched to 50 ohms with a return loss in the order of

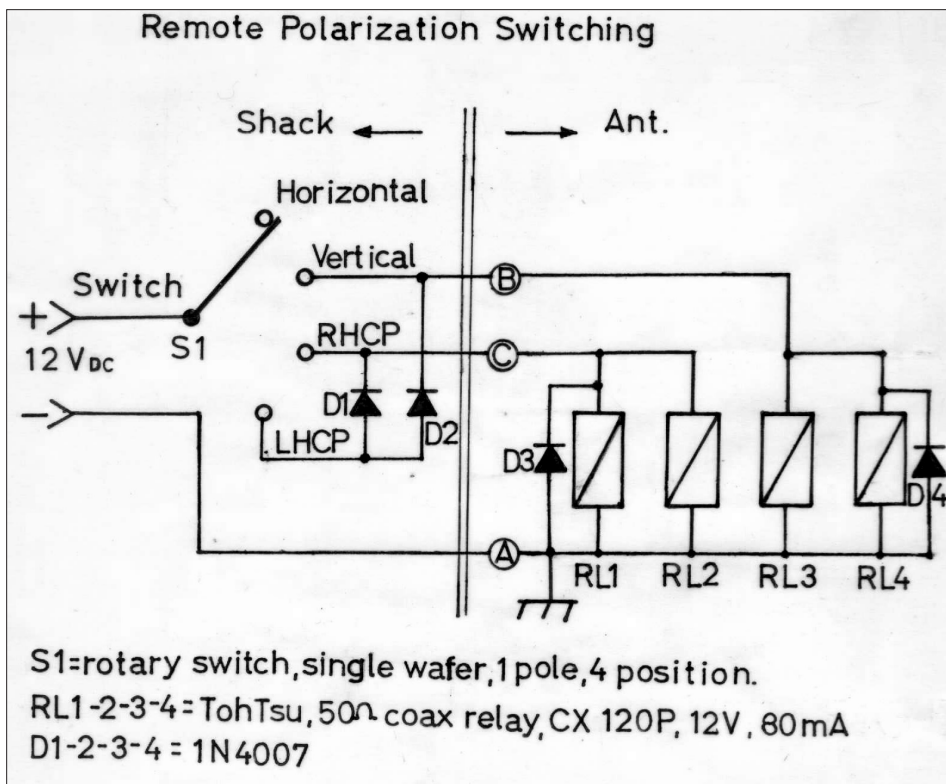


Figure 2. The schematic diagram for remote polarization switching (see Part-1 for details).

20 to 25 db, the power feeding the switcher is divided in two equal parts as explained in Reference 3, Chapter 8, pages 8-10. The total switcher insertion loss under these conditions is 0.35 dB.

Polarization	Return Loss (dB)	VSWR
Horizontal	23	1.17
Vertical	23	1.15
RHCP	26	1.19
LHCP	24	1.14
X1 & X2 Open Circuit	2	9.54
Insertion Loss = .35 dB on each branch		

Table 1.

Polarization	Return Loss (dB)	VSWR
Horizontal	23	1.15
Vertical	22	1.18
RHCP	24	1.13
LHCP	25	1.12

Table 2.

Before mounting the new switcher on the antenna, the return loss and VSWR of each dipole was independently measured for reference with the following results:

Single rear dipole:

return loss 22 dB (VSWR = 1.17)

Single front dipole:

return loss 19 dB (VSWR = 1.25)

In addition, the antenna was tested using its original CS-2 switcher and the return loss while operating in RHCP was 23 dB (VSWR = 1.15) while operating in LHCP it was 25 dB (VSWR = 1.12).

Finally the new switcher was mounted on the antenna and the measured VSWR is shown in Table 2.

Reference Yagi TX Mode	Antenna Under Test	
	Reference Level H	0dB
	V	-18.0dB
Horizontal	RHCP	-3.0dB
	LHCP	-3.5dB
	Reference Level V	0dB
	H	-17.5dB
Vertical	RHCP	-3.5dB
	LHCP	-3.0dB
	Reference Level LHCP	0dB
	LHCP	-16.0dB
RHCP	H	-3.0dB
	V	-4.0dB
	Reference Level LHCP	0dB
	RHCP	-15.5dB
LHCP	H	-3.5dB
	V	-4.0dB

Table 3.

The sense of polarization of the antenna with the new switcher was verified using for reference two cross mounted linearly polarized 9 element Yagis whose driving elements H and V were supplied by a phasing harness to get RHCP or LHCP when necessary.

Using the reference Yagis in TX mode for each polarization and the antenna under test in RX mode for each switched polarization, Table 3 shows the axial ratios in dB against a 0 dB reference level.

Circularity Test

The antenna under test was switched to receive in circular polarization and the longitudinal axis of the boom was slowly rotated by 360° against a fixed linearly polarized 9 element Yagi transmitting in vertical or in horizontal polarization. A maximum change of 2 dB at 435.5 MHz was measured while receiving in each circular polarization RHCP or LHCP.

Transmitting a RHCP reference signal and receiving with the same RHCP sense while axially rotating the antenna under test by 360° over the boom, less than +/-0.5 dB in signal strength was measured on spectrum analyzer set at 2 dB/div.

The antenna was tested with a 50 ohm coax cable and a shielded 12 VDC switching line coming off the rear of the boom as in Photo 11 as recommended in the 435-40CX manual. A very small difference in VSWR was measured when these two cables were well laced together along the boom and coming off horizontally as they leave the mast mount aluminum plate visible in Photo-10 and run over to the support pole in a null position as recommended in Reference 4.

By the way, since the antenna generates both a linear or a circular wavefront depending on polarization switching, it is better to run both cables off the rear of the boom whenever possible because no metallic object can be in close proximity without cutting this field and thereby disturbing the gain, VSWR, pattern and ellipticity.

Mounting the antenna in X configuration and following the recommendations in Reference 4 it is possible to get excellent results using a metallic support pole and running both cables along the boom.

Operation

Before enclosing the switcher in the box the antenna was tested by receiving FO-29 from a balcony nearby the shack using a FT-817 without a preamplifier.

In spite of the low sensitivity of 0.125 uV for 10 dB S/N corresponding to a noise figure NF = 5.14 dB, a very good signal was received from the CW beacon at 435.795 MHz. Thanks to IZ1ERR and IZ1DSJ a video was produced that is available at:



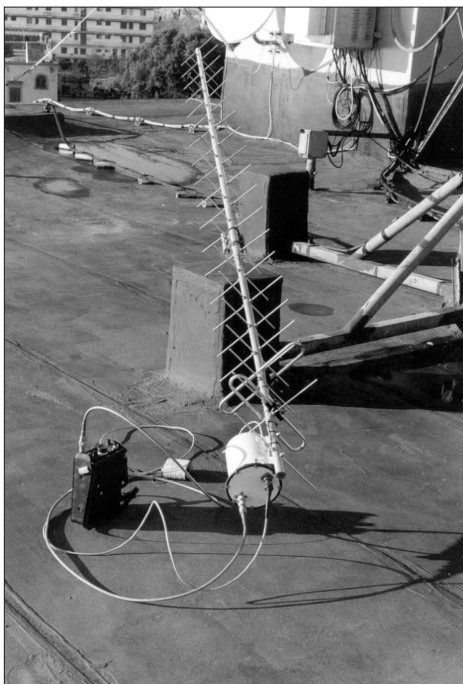


Photo 10. Before mounting the antenna on the mast, a test was performed receiving FO-29 from the top of the terrace using an FT-790R without a preamplifier.

<http://video.google.it/videoplay?docid=4632795847790566731&q=i8cvs>

Before mounting the antenna on the mast a new test was performed receiving FO-29 from top of the large terrace using an FT-790R again without preamplifier (Photos 10a and 11).

However, in spite the low sensitivity of 0.16 μ V for a ratio of 10 dB S/N corresponding to a noise figure NF = 7.29 dB, excellent signals were received on CW and SSB.

The antenna was held by hand and was manually pointed in the direction of the hill from where strong vertically polarized white noise is radiated by several FM/TV stations. Switching from vertical to horizontal polarization, the 20 dB over the noise floor vertically polarized offending signal disappeared completely allowing reception of the FO-29 beacon as soon as the bird was just above the horizon at AOS in direction of the hill.

Then, attention was focused on traffic following SSB QSO's between IZ1ERR and IW4DVZ. They were alerted to mention time to time for reference the best polarization modes that they were using while receiving FO-29 during the whole orbit. Their circular polarization modes were found to be compatible with the circular polarizations actually switched for the best S/N at the antenna under test.

During polarization switching for maximum signal on high passes it was noted that FO-29 in general is best received using RHCP and seldom LHCP but the sense of circular polarization changes very often during one orbit while the horizontal polarization helps at AOS and LOS when the elevation is low because the horizontal polarization strongly attenuates the vertically polarized urban man-made noise particularly when the antenna is pointed with low elevation in direction of the city.

Conclusion

This four-polarization switcher on a 70 cm crossed Yagi has proven to be definitely

w o r t h w h i l e . While a circularly polarized antenna cannot outperform a linearly polarized antenna most of the time, in cases where an interfering signal can be eliminated by switching from circular to linear or from horizontal to vertical polarization, this can be quite effective in eliminating the interference. The antenna can also be switched between polarizations so that a single antenna can be used for both satellite and tropo activity as required.

The apparent additional complexity of this four-polarization switcher can be built at a competitive cost, particularly if the actual two-mode circularity switcher originally supplied with the 70 cm crossed Yagi must be replaced for maintenance.

References

- [1] "A Remote Polarization Switching Unit for Crossed-Yagi Antennas" by H. Stoll, DF7SO, *VHF Communications*, 1/1980
- [2] "Notice sur la Polarization Circulaire sur 144/146 MHz et 432/438 MHz" by F9FT at: http://f5ad.free.fr/QSP_Antennes/ANT-QSP_F9FT_polcircfr.pdf
- [3] *The Satellite Experimenter's Handbook* by Martin Davidoff, K2UBC, ISBN 0-87259-318-5, ARRL Order No. 3185

[4] <http://www.g6ljb.com/fibermetalboom.htm> 

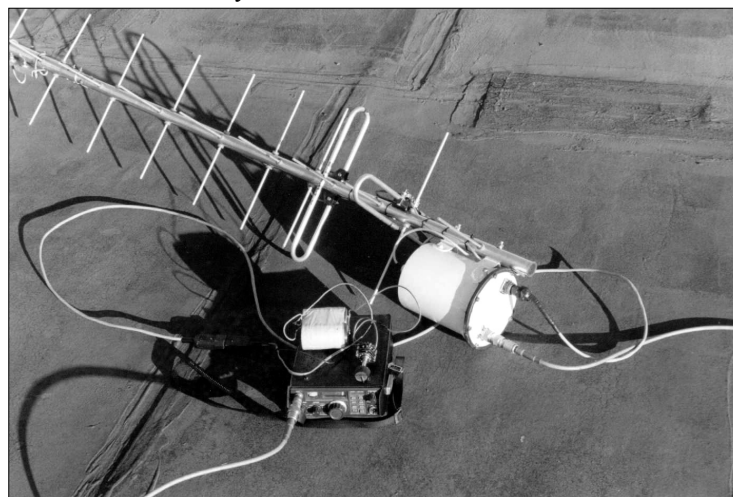


Photo 11. The antenna was tested with a 50 ohm coax cable and a shielded 12 VDC switching line coming off the rear of the boom as recommended by KLM in the 435-40CX manual.



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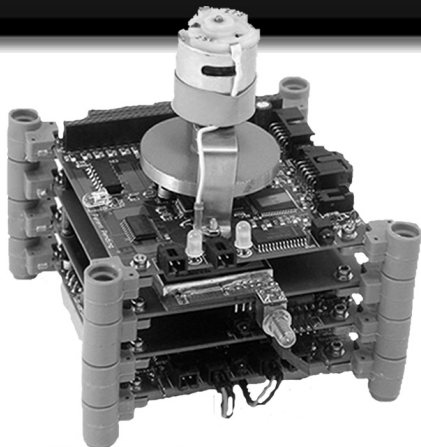
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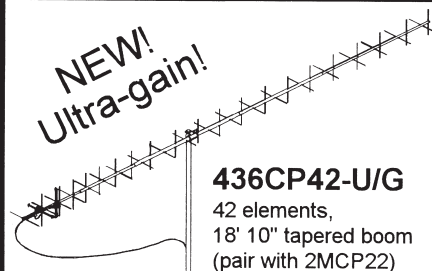
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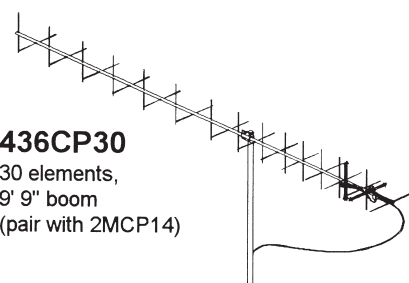
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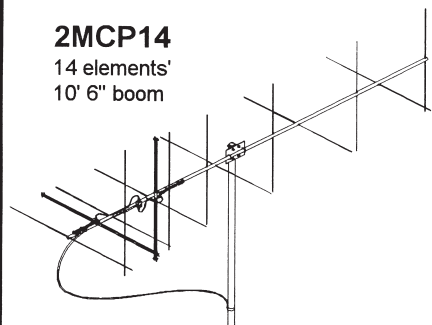
436CP42-U/G

42 elements,
18' 10" tapered boom
(pair with 2MCP22)



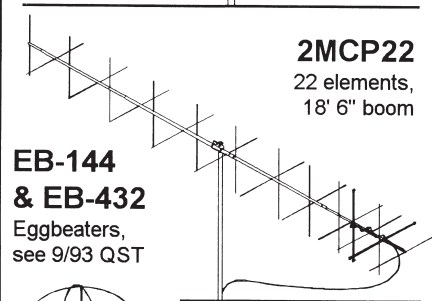
436CP30

30 elements,
9' 9" boom
(pair with 2MCP14)



2MCP14

14 elements'
10' 6" boom

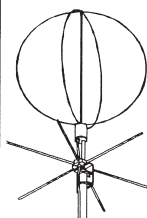


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TECHNICAL ACHIEVEMENT

From the ARRL Atlantic Division News:

The Atlantic Division Technical Achievement Award is awarded to Jim Sanford, WB4GCS.

Jim was first licensed in the sixth grade and was a 1976 graduate of the US Naval Academy. While active in the Navy, he was active with Navy MARS stations both on ships and on shore.

Jim was nominated for his involvement with the AMSAT program. He is currently serving as the Project Manager for the AMSAT OSCAR Eagle project. This project is the next generation high earth orbit satellite under construction now by AMSAT North America. Eagle will provide many services and reliable communications on bands not previously available and will build upon technology developed by AMSAT-NA for use in P3E. Eagle is currently in development stage although the major components are finished (and installed on P3E) and other components such as the software defined transponder have been demonstrated.

AMSAT is the North American distributor of **SatPC32**, a tracking program designed for ham satellite applications. For Windows 95, 98, NT, ME, 2000, XP.

Version 12.4 now supports Labjack U12 and W0LMD rotor controllers and Doppler tuning for Yaesu FT-817/857/897.

Features:

- Version 12.4 also supports automatic Internet download of Keplerian elements.
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- Doppler tuning with on-screen frequency displays. Radio models supported: Yaesu FT-847, FT-736R, FT-817, FT-857, FT-897, ICOM IC-820H, IC-821H, IC-910H and other ICOM radios, Kenwood TS-790 and TS-2000 DDE client programs
- "Transparent" VFO-knob tuning in addition to keyboard and mouse tuning.
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- Controls subaudible tone on FT-847, FT-736R, FT-817/857/897, and IC-910H.
- Includes a non-graphical version and programs that output lists to the screen, printer, or a file.
- Interfaces with WiSP, with user-defined satellite switching priority.
- Includes a separate program for tracking the Sun and Moon.

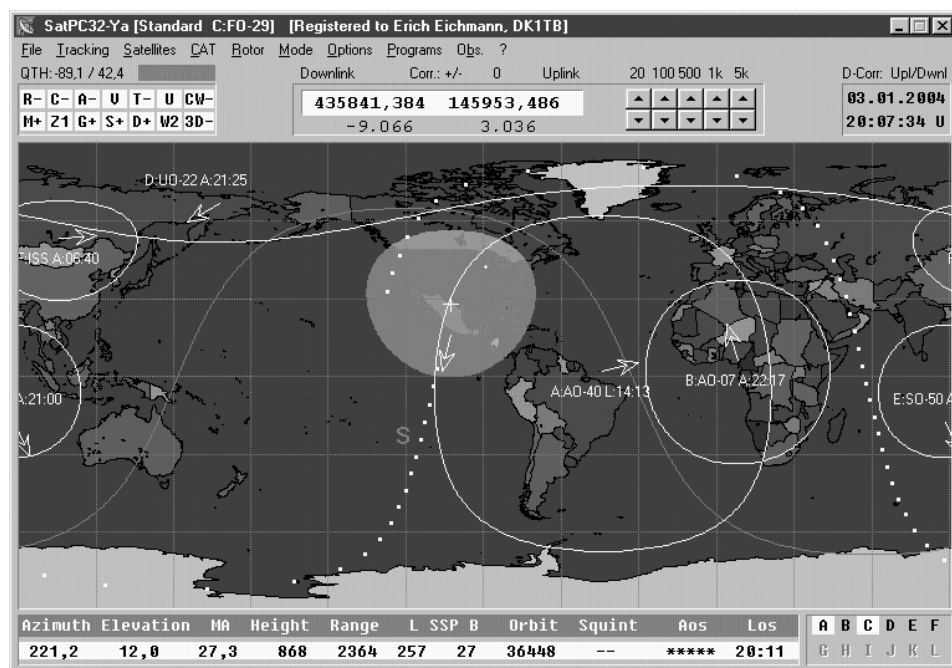
Price is \$45 for AMSAT members, \$50 for non-members, on CD-ROM.

A demo version may be downloaded from <http://www.dk1tb.de/indexeng.htm>

A registration password for the demo version is \$40 (members), \$45 (non-members).

Order by calling 1-888-322-6728, or use the online shop at www.amsat.org.

The author DK1TB donated SatPC32 to AMSAT. All proceeds support AMSAT.



AMSAT at the Glendale, Arizona Hamfest

by Patrick Stoddard, WD9EWK/VA7EWK, wd9ewk@amsat.org

After my first time working at an AMSAT hamfest table last month, I was looking forward to this hamfest on the west side of the Phoenix area. Gerry, VE4GTB/KD7MDB, and I took care of the table and we answered lots of questions and had 4 passes (2 on SO-50, 2 on AO-51) for demonstrations that attracted the interest of the hamfest crowd. We had a good time despite the bitter cold and small turnout and also sold a fair amount of AMSAT items to hams looking to try the satellites themselves.

The hamfest organizers, the Thunderbird Amateur Radio Club (W7TBC; <http://www.w7tbc.org/>) had requested the special callsign W7W for use by their HF special-event station. Gerry had asked them if we could also use the W7W call during our satellite demonstrations and we were told, "Sure". I posted an announcement on the AMSAT-BB mailing list and on a few other lists of the upcoming satellite activity, and we were ready to go.

Saturday morning started early. I arrived at the hamfest site at 0530 local (1230 UTC) and Gerry was already there. We were told by the organizers to set up next to their HF station and one of the Thunderbird club members made sure we had a covered spot in case of rain. We set up our tables with the AMSAT merchandise and my equipment (IC-2720H mobile radio, 12V/20Ah gel-cell batteries, Arrow Antennas handheld Yagi, Sony digital voice recorder, external speaker, laptop with Nova running during the demonstrations to show where the satellites were). Our first pass was on SO-50 at 1317 UTC and we were ready for that.

The first SO-50 pass went from south to east and since it was an early pass, we were not

sure there would be many stations showing up. We made two contacts during the pass, with Angelo, N5UXT, as our first satellite contact as W7W (thanks for being up early, Angelo!). One other contact before the end of the pass with a VE3 and then back to answering questions until 1500-1520 UTC and an SO-50 pass followed immediately by an AO-51 pass.

The SO-50 pass around 1500 UTC went to the west, and being early for those in western North America, I did not expect much activity. We were happy to make 3 contacts, two Mexican stations plus Zach, KM7I, in Seattle before we moved over to AO-51. We heard the announcements from Gould, WA4SXM, that there was testing in progress, so we kept listening and hoping the satellite would be available for part of the pass since it would cover most of North America. The testing ended, leaving a couple of minutes to make two quick contacts before the satellite went out of range.

The final AO-51 pass, around 1647-1702 UTC, started out with a surprise. The crowd and I heard a couple of hams chatting on 435.310 MHz, which was where I ready to hear AO-51 at the start of the pass. I quickly went onto that frequency and asked those hams to move to another frequency, which they did, and then we

made 10 contacts with stations in the western USA, Alaska and Mexico to conclude our satellite demonstrations. Larry, WA6DIR, in California was the last station in the W7W satellite log.

At the end of the morning, we had a total of 17 contacts in our satellite log. We made 12 contacts on AO-51 and 5 on SO-50 with stations in 8 US states (Alaska, Arizona,



VE4GTB/KD7MDB (l) and WD9EWK/VA7EWK man their table at the Glendale, AZ hamfest.

California, Louisiana, Montana, Ohio, Oregon and Washington state), one Canadian province (Ontario) and two Mexican states (Baja California and Zacatecas). The hamfest organizers now have a copy of the satellite log, to combine with their HF log for their records and to be able to answer any QSL requests from the satellite demonstrations.

Thanks to everyone who stopped by our table, and for those we made contact with on the satellites.

73,

Patrick

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The Orbital Classroom

Column #8

"What Hath God Wrought?"

© 2007 by Prof. H. Paul Shuch, N6TX, n6tx@amsat.org

AMSAT Director of Education

Morse, the digital communications code first demonstrated to a waiting world by Samuel F.B. Morse in 1844, is now officially obsolete. And so, I imagine, are many of us who still employ it.

First used to cross continents, and then (half a century later) to cross oceans, Morse code (and its successors) wrought the communications revolution, shrinking and linking our globe, and ultimately facilitating collaborative science, as is practiced by AMSAT. For the past century, it has been the primary means by which Amateur Radio operators (to which fraternity most AMSAT members belong) communicated with their counterparts in distant lands.

Ah, but no more. Several years ago, the International Telecommunications Union deemed Morse code skills optional. Prior to that time, member states issuing ham radio licenses were required to compel applicants to demonstrate proficiency in that archaic artform. When the Morse code requirement was abandoned by the ITU, individual nations were free to drop the code test from their licensing procedures. Many did -- but not the United States, the tail that wags the telecom dog.

But, in 2006, the USA's Federal Communications Commission dropped the other dit and deducted Morse proficiency from the price of admission into the ham radio fraternity. The resulting controversy

pitted *us* against *them*, with *us* being those already skilled in this particular digital communications mode, and *them* being those who preferred more modern means of sharing ones and zeroes.

Perhaps you saw the video clip of the digital showdown held on late night TV some months back. Two aging Morse code-using hams (both AMSAT members, I am proud to say) were pitted against a pair of championship text messaging youth, in transmitting a short message across the TV studio. The telegraphers from a bygone era won hands down! But, we're comparing keys to keypads here; the contest actually measured the efficacy of the input device, more than it did the relative merits of the digital modes in question.

What has all this to do with AMSAT? On the surface, the FCC's Morse decision would seem to involve us only peripherally. Certainly, most AMSAT members happen to be licensed by our respective governments to engage in Amateur Radio communications. We presume that *all* who actually transmit via our satellites are so licensed, and we highly encourage licensing classes for any students engaged in university CubeSat projects. Control operators for any satellite using amateur frequencies must of course be licensed hams. So, by syllogism, Morse code proficiency is relevant to AMSAT, at least at some level.

In a broader sense, it can be argued, Morse code is irrelevant to the theory or practice of satellite communications. Much satellite activity is on voice modes, either SSB or FM. The predominant digital mode used on today's birds is ASCII, not Morse, and (as far as I know) no licensing agency ever administered a 5 WPM ASCII test. Even our satellite telemetry has pretty much abandoned CW. The days of counting HIs to determine temperature (as was done with OSCAR I), or of manually reducing 3-digit Morse groups to read voltage, current and transmitter power (popular in the days of OSCARs 6, 7 and 8) are well behind us. Unless we choose to use CW for a QSO (some still do, but that mode is declining in popularity), any skills in radiotelegraphy are becoming entirely secondary to our technological mission. So, who cares what the ITU, the FCC, or any other regulating body may dictate.

On the third hand (and there's relevance here to AMSAT's educational mission, ostensibly the focus of this column), it is reasonable to assume that, with the elimination of a Morse code requirement, the barriers to entry into the ranks of the radio amateurs have been reduced. Whether you are a Morsophile or a Morsophobe, you will have to admit that this could result in the world coining more licensed hams. And, since AMSAT draws its membership base largely from among the ranks of the world's radio amateurs, might this not result in more potential members? I think this is at least an arguable conclusion.

In which case, I thank you, Mr. ITU (and you, Ms. FCC), for opening the doors to greater AMSAT membership. Here we have a chance to attract wider participation in the amateur satellite enterprise. This can have nothing but positive results, whether we spell that in dits and dahs, or bits or duhs.

... — . —



Chip Margelli, K7JA, squares off with a hapless "texter" on NBC's Tonight Show with Jay Leno. Chip and his partner won hands down.



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... continued from page 5

References

- [1] *The AMSAT Journal*, March/April 2007, page 4.
- [2] The software is written in Visual Basic 6.0 specifically for the IC-910 with CI-V interface. The software has only been tested with Windows XP. The source code and executable file are available for the price of an e-mail request to the author.
- [3] M² Circular Polarization Yagi documentation. 🌐

Table 1		
SWR	2 Meters	↔
	70 CM	↓
De-sensing		↑
Signal Strength	AO-51	↑
	AO-27	↑
Signal Fade	AO-51	↔
	AO-27	↑



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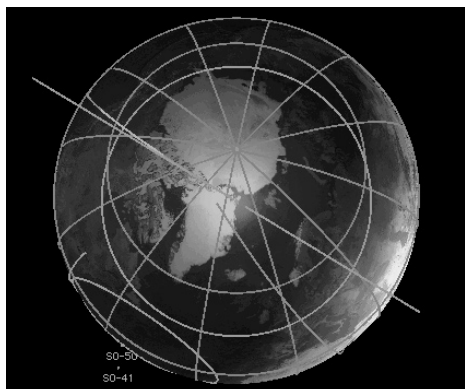
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AMSAT Eagle Update

James A. Sanford, PE, WB4GCS, wb4gcs@amsat.org

Eagle Project Manager

Our Vision is to deploy high earth orbit satellite systems that offer daily coverage by 2009 and continuous coverage by 2012...



I begin this article with a couple of apologies. First, I apologize for not being at Dayton. Second, I apologize for not having the working demonstrations that I'd intended. I was minutes away from powering up the demos and hours away from heading for Dayton, when events transpired to rearrange (temporarily) my priorities. Thanks to a Herculean effort by my wife, Pat, KC4WTT, and Kevin Smith, N3HKQ, the U-band receiver and a concept model for an S2-band receiver were available at Dayton for static display.

That's right, we have a concept S2-band receiver, courtesy of Bill Ress, N6GHZ. Bill expressed an interest in doing microwave work for Eagle at The AMSAT Symposium in San Francisco. He then took it upon himself to develop a concept downconverter, shown in Photo 1. If you look closely at the photo, you'll see distinct circuit boards. Each represents a different module in the block diagram, which you will soon be able to see on EaglePedia. Bill says that he developed it this way to allow exploration of various components in various stages. This device will never fly, but will be very useful in developing and testing leading to flight hardware for the ACP. I thank Bill for his initiative and efforts on behalf of Eagle and I recognize the quality of the workmanship. Concerning the ACP, discussions on phased array antenna design, led by Tom Clark, K3IO, are continuing to explore options.

Photo 2 shows the U-band receiver that was shown at Dayton. I've been discussing this receiver, designed by John Stephenson, KD6OZH, for several months and Juan Rivera,

WA6HTP, has done a masterful job in assembling a team to build and test it. The Project Oscar team working on this receiver consists of Dave Hartzell, N0TGD, Dave Black, W6MOF, Don Ferguson, KD6IRE, Greg Samsonoff, KI6IKG, Dave Smith, W6TE, and Juan. Stephen Moroco, KC0FTQ, and Bob Davis, KF4KSS, provided distance support. If you peruse the U-Band receiver pages on EaglePedia, you'll be impressed by the tremendous job Juan has done in documenting each stage of construction and debugging for this receiver. I've looked at this thing up close; their workmanship is excellent.

Photo 3 shows a prototype for a high efficiency V-band power amplifier designed by Marc Franco, N2UO. This amplifier, using a SiC MESFET device, has 20 watts output and has been measured at greater than 80% DC-to-RF efficiency. Spurs and harmonics are greater than 50db down, and it responds nicely to modulation of the power supply. That is, the RF voltage to drain voltage linearity is excellent. These characteristics make it ideal for use in an SDX-controlled HELAPS (or Envelope Elimination and Restoration [EER]) amplifier. I'm told that AMSAT transmitters have historically had efficiencies of 30% or less, so this amplifier, enabled by the SDX and emerging RF device technologies, portends great things for Eagle. Look for more details on this amplifier in various publications in the near future. I thank and congratulate Marc for his innovative work.

Bob Davis showed a half-scale structure model at Dayton. This model represents the current thinking on the structure size and shape, driven by known launch possibilities, power generation requirements, and antenna real estate requirements. This will continue

to be refined in the near future as various requirements get developed and refined.

Ken Erlandes, N2WWD, has done a 10-year orbital study, focusing on Earth shadowing. This study reveals some extended periods of time with no eclipse and several periods where eclipses will be 2 to 2.6 hours in duration. This information will go a long way in defining thermal and power issues, which must be dealt with, and will probably effect operations. While we'd like to continue operation of some payloads during eclipse, we will probably not be able to operate all. Although the structure design is intended to reduce, but not eliminate, the dependency of power generated versus sun-angle, when the sun is in eclipse, power generation is ZERO, and we must deal with that reality.

By now I hope you've seen the announcements for the 2007 AMSAT Symposium in Pittsburgh, PA. Pat, KC4WTT, and Kevin, N3HKQ, are leading a great team that is working to show you a first-class event. The hotel AMSAT selected is the same facility that accommodated us so well on short notice two years ago. The hotel is undergoing a nice renovation, so we will have clean new facilities to enjoy. Our hosts, the Wireless Association of the South Hills (WASH) and several surrounding area clubs, are eager to host us. I expect that the Eagle team will have much to say and show this year, so I'd really like to see each of you at Symposium. See the AMSAT Web site for details.

Finally, I'd like to thank the Rochester Amateur Radio Association and the

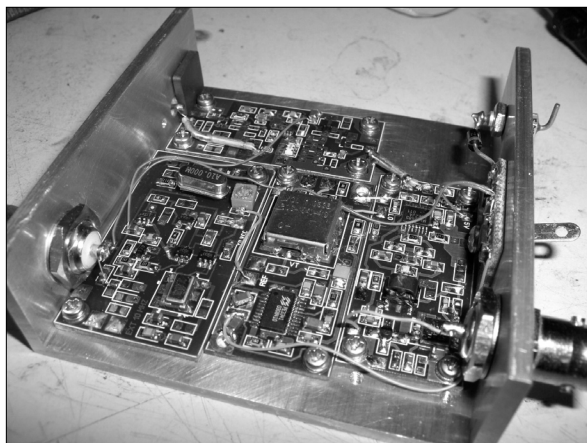


Photo 1

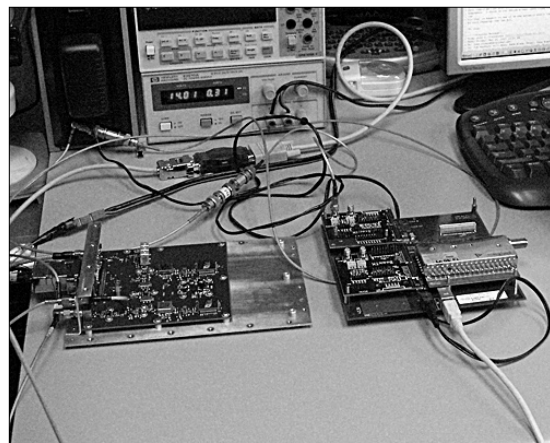


Photo 2

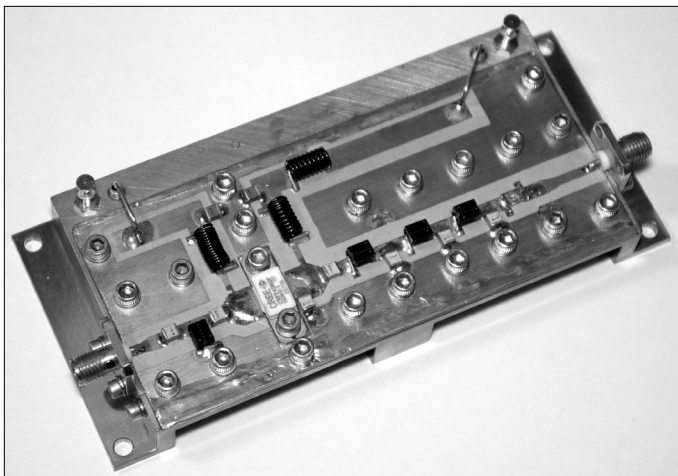


Photo 3



Photo 4. Greg, Dave and Don testing the U-band receiver.

ARRL Mid-Atlantic region folks for their tremendous hospitality this past weekend at the Rochester hamfest and ARRL convention. Rochester is a very nice show, and I especially enjoyed meeting Richard, N2SPI, and Sally Crowe – they sure know

how to show off AMSAT, and do a fantastic demonstration of the “easysats.”

As always, questions and comments to, wb4gcs@amsat.org. ☺

AMSAT Groups Make Donation to AMSAT-DL to Facilitate Completion of P3E Satellite Amateur Radio Satellite

Following a meeting between representatives of the AMSAT groups from North America (AMSAT-NA), The United Kingdom (AMSAT-UK) and Germany (AMSAT-DL), a decision has been made by AMSAT-NA and AMSAT-UK to donate a total of 40,000 Euros to AMSAT-DL for the purpose of funding the continued operation of the “Zentrales Entwicklungslabor für Elektronik”, (Central Development Lab for Electronics, aka “The ZEL”).

The ZEL was established over 20 years ago at the University of Marburg by AMSAT-DL for the purpose of satellite construction. It is in this suite of workshops that several amateur space frames have been constructed, integrated and tested, including the famous OSCAR 13. The ZEL is staffed by approximately 10 engineers, technicians, administrators, etc., who are a mixture of University employees and AMSAT-DL volunteers. The major current project in the ZEL is the construction of the Phase 3E satellite (P3E). Although construction is centered at the ZEL, many of the components come from other parts of the world, including the Integrated Housekeeping Unit (IHU-3), the CAN-Do bus interface modules, and the STAR camera from AMSAT-NA and the U/V SDX transponder module from AMSAT-UK.

P3E is considered vital to the Amateur Radio space community for a variety of reasons. Currently there is no high orbit satellite carrying analog transponders allowing multiple simultaneous DX contacts. There are Amateur Radio satellites in low earth orbit but these, because of their low orbit, only support relatively short range contacts and are only visible for short periods of time (e.g. 10 - 15 minutes). The proposed orbit of P3E will cause it to be visible from Amateur Radio stations on earth for several hours at a time, allowing increased periods of operation and experimentation.

P3E is considered a ‘low risk’ approach based on many of the design parameters of the hugely successful OSCAR 13. To keep costs low, it is based on a flight spare chassis left over from the OSCAR 13 development program. There will, however, be several new innovations. For example, the Mode U/V transponder, with a planned 80 KHz bandwidth, will be based on DSP technology using software developed in the UK and SDR HELAPS jointly developed with AMSAT-NA. The IHU-3 will be a new development based on a unit successfully tested on OSCAR-40. There will be several other experiments which will test techniques needed for the proposed flight of an Amateur Radio spacecraft to Mars (Phase 5A), for

example, a low power beacon simulating the weak signals that it will send from the Phase 5A satellite (P5A) on its journey to Mars. This will allow radio amateurs to test their stations in readiness for P5A.

The optimal years for launching a Mars bound spacecraft are 2009 and 2011 so it is important that P3E be launched as soon as possible. This is currently planned to be at the end of 2008. It is realized that the next important step is to obtain an agreement with a suitable launch agency to undertake to fly the satellite.

Further Resources

Previous progress reports on P3E:

<http://www.amsat-dl.org/p3e/>

Photographs of the ZEL:

<http://n4hy.smugmug.com/gallery/383989/> and at:

http://www.uk.amsat.org/index.php?option=com_wrapper&Itemid=94

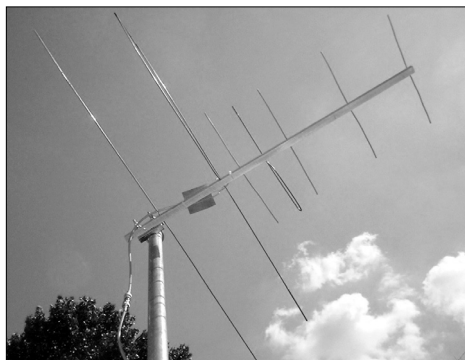
Further information can be obtained from Jim Heck, G3WGM, AMSAT-UK: g3wgm@amsat.org ☺



Cheap Antennas for the AMSAT LEOs

by Kent Britain, WA5VJB, wa5vjb@wa5vjb.com

Hand-held, dual-band antennas are popular for QSO's through many of the Low Earth Orbit satellites. This article covers several 145 MHz antennas, a larger number of 435 MHz antennas and how to combine them into one antenna.



A Cheap LEO antenna.

Got a STRONG arm or plan to use your antenna with a tripod? Then by all means the 4-element 145 MHz and the 8-element 435 MHz antennas can be used together. Or



Drew, KO4MA, using the Cheap LEO antenna during a Dayton AMSAT LEO demonstration.

there is the 2 element 145 and 5 element 435 MHz antennas used in the AMSAT demonstrations. This combination is only 32 inches long. Need something much lighter for backpacking? How about using a 20-inch long, 2-element antenna on 145 MHz and a 3-element antenna on 435 MHz? For the 'Arrow' enthusiasts, this homemade, smaller 2 elements on 145 MHz and 3 elements on 435 MHz antenna will actually outperform the standard 'Arrow'. *More on that in a bit.*

One popular commercial antenna mounts the elements on the boom 90 degrees to each other. This is a mechanical, not really an electrical, decision. On this antenna the elements can be mounted crossways, but mounting them flat makes the antenna much easier to lie down in the back of the truck or store in the garage.

Construction

For the boom 5/8 x 5/8" or 3/4 x 3/4" wood works well. If you plan to mount the antenna outside for a long term, a coat of spar varnish, spray enamel or some of that waterproofing stuff you use on wood decks will add years to the life of the antenna.

For the elements I used 1/8" material. The 435 MHz reflector and directors were from a roll of Radio Shack Aluminum Ground Rod wire - stock number RS 15-035. Forty feet will run you about 5 bucks and make a lot of antenna elements. But #10 bare copper wire, bronze welding rod and hobby tubing have all been used. If you want to use 3/16" diameter elements, cut them .2 inches shorter than the dimensions in the tables to compensate for the thicker material. The 2 meter elements were all made from bronze or brass welding rod. I like to use something I can solder the coax to and the welding rod solders well.

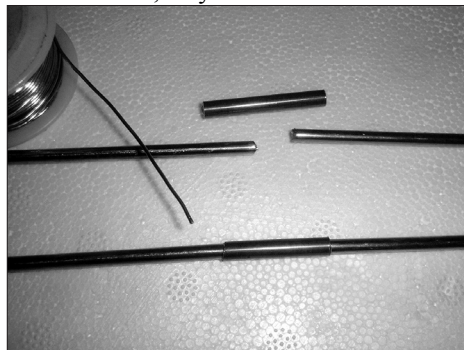
Element Splicing

The welding rod is only 36" long. A section of 1/8" ID copper or brass hobby tubing makes a good splice. Just slip it on and solder them together. Save some of that hobby tubing. If you have a habit of "I trimmed the antenna twice, and it's still too short!" then you can solder a piece on the end of the driven element and start over.

I usually hold the elements in place on the boom with a drop of Super Glue. But silicone glue and even paint have been used.

The 145/435 MHz Band Splitter Winding the Band Splitter Coils

The band splitter is just a 250 MHz high pass filter and a 250 MHz low pass filter connected together. This doesn't have to be very complex, or even very accurate. As long as the filters cut off somewhere between 200 and 400 MHz, they will work fine. So if the



Splicing technique.

coils get squished, just bend them kind of back in shape, and go for it. This one is built cheap, just out in the air on a piece of printed circuit board. You can build the splitter into a box if you like, with connectors and all, but it's not going to change their performance. And this band splitter even makes a good project is you want to use two other 145/435 MHz antennas.

Remember, we are not trying to filter out harmonics, just make the 2 meter signal go to the 2 Meter antenna and the 435 MHz signal go to the 435 MHz antenna.

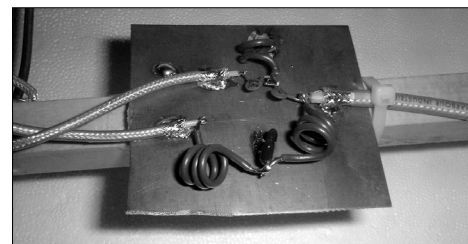
Parts List

435 MHz high pass filter

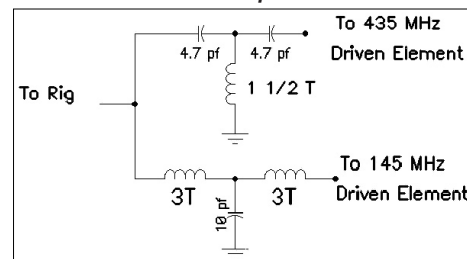
- 2 4.7 pf caps
- 1 Coil, 1-1/2 turns #18 or #20 wire wound on a pencil

145 MHz low pass filter

- 1 10 pf caps
- 2 Coils, 3 turns #18 or #20 wire wound on a pencil



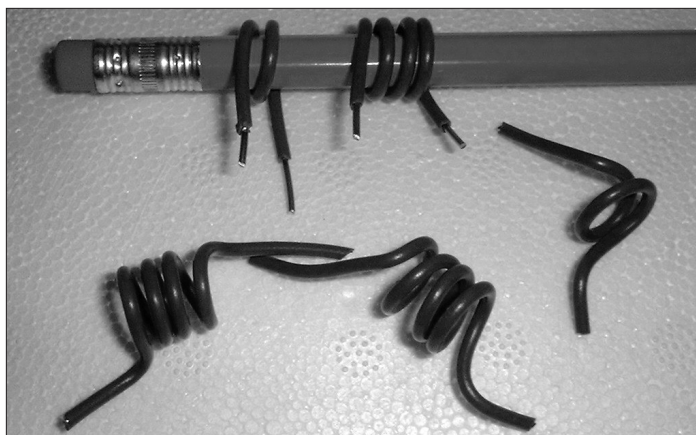
The 145/435 MHz band splitter.



Splitter schematic.

You're too late; I have already been asked if it needs to be a #2 or a #3 pencil. For the record I wound my coils on a red grading pencil. For those of you with a more mature sense of humor, just about any wood pencil makes a .3" coil form.

We are frequency spitting the signals, not power dividing, so the length of the coax between the splitter and the antenna is not critical. You want to keep the coax as short a practical, but its exact length is not important. Got a box of 4.7 pf's? You can use 2 of them instead of the 10 pf. Be sure to keep those leads very short. I used Teflon



Winding the band splitter coils.

coax on my splitter, it solders so much easier than foam RG-58, but you're free to build it in a box and use connectors if you like, but it's not really necessary.

Power Handling

Power handling of this band splitter depends almost entirely on your caps. With 50-volt caps, 20 watts is about your limit. Dig up some 1 kV caps, and the coax will probably melt first as you warm up that 4CX250.

One of my first prototypes tried to use the last 2 meter director as the 435 MHz reflector. An interesting idea to save weight and make the antenna shorter, but performance suffered too much. So all versions now have a reflector on the 435 MHz portion. The last 145 MHz director and the 435 MHz reflector will interact. If you plan to mount them in the same plane, *which I find easiest*, space them 3 inches apart.

These J driven elements usually bring several comments from people new to "Cheap Yagis". The shield of the coax goes near the center of the top of the element. This is a voltage null and directly soldering the coax to the driven element has a lot of advantages.

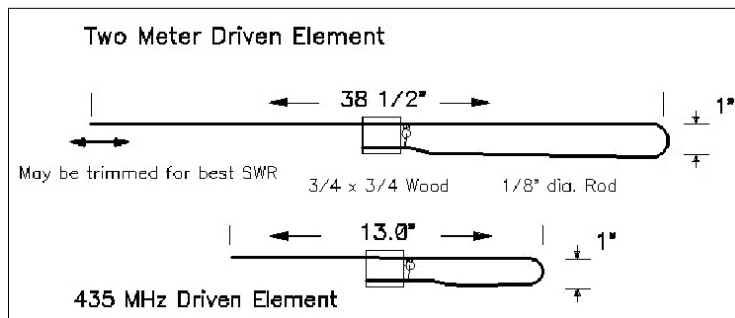
The tip of the coax goes to the tip of the J. So you can think of this driven element as 3/4ths of a folded dipole or a gamma match with no capacitor. In free space, the J driven element has about a 150 ohm impedance. As

other elements are added, they load down the impedance of the driven element. If the antenna has relatively wide element spacing, then a direct match to 75 ohms is possible. Bring in the reflector and directors a little closer, then you have a direct match to 50 ohms. So the impedance matching is the length and spacing of the other elements. Just build the antenna to the dimensions, solder on the coax and start talking. No tuning required.

Tuning it Up

For the ultimate in performance, connect a coax to just the 2 meter portion and trim the free end of the J for best SWR for your favorite LEO uplink frequency. Then connect the coax to just the 435 MHz portion and again trim the free end of the element for best SWR. Now install the band splitter and this time tweak the coil spacing for best SWR at your spot frequencies. You have now gotten the last .1 dB out of the antenna. For everyone else, just build the antenna to the dimensions and the SWR will be under 2 to 1 on both frequencies. Just build it and talk. The design is pretty idiot resistant.

This antenna can be built in 30 combinations of elements and polarization's. One should fit your need. The 2 elements on 145 and 5 elements on 435 MHz combination has done great in the field tests. Now you can have fun with the LEO's for less than \$10.



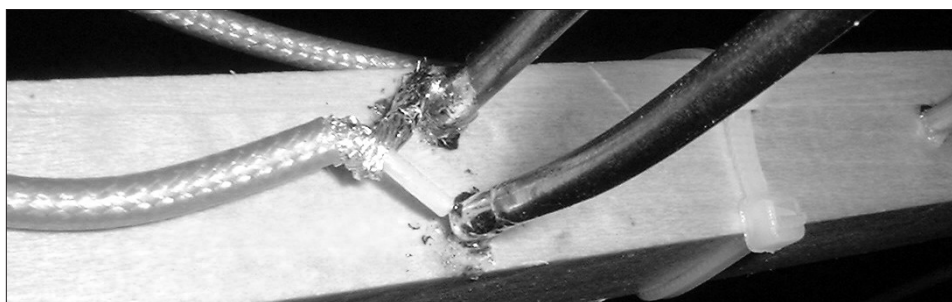
Driven element dimensions, both bands.

My first question was why the "Arrow" has performed so poorly in the AMSAT demos. Arrows have been on the antenna range at several conferences showing 435 MHz gains as low as 4 dBi. I would like to thank Sam, G4DDK, for sending me the detailed dimensions of his Arrow antenna. I built a NEC model of the 435 MHz portion, and the model showed the forward gain peak to be near 457 MHz, not 435 MHz.

When you change the diameter of an element, you also have to change the length of that element to compensate for the new diameter. Two common ways to mount elements are to make the antenna element part of the boom, or using insulators, electrically isolate the element from the boom. When you make the element part of the boom, you radically change the diameter of the element in that area. Now the length of the element must be changed to allow for this new diameter. This is called the "Boom Correction Factor". I try to avoid correction factors as best I can by using thin wood booms with my Cheap Yagis. I don't know the history of the development of the Arrow antenna, but the model suggests that the dimensions for a 435 MHz Yagi using insulated elements were used for Arrow, but mechanically the elements were made electrically part of boom. It appears no Boom Correction Factor was used.

Ed, WA4SWJ, sent me an Arrow to play with on the antenna range, so stand by for another article. It looks like we can squeeze several dB more gain out of the basic Arrow. At the Central States VHF Society Antenna range we measured 7.0 dBd gain out of the 435 MHz section of the Arrow. Several simple modifications increased gain .3 dB, but I know there are more dB's hiding in there. More details will be provided in a future article.

For even longer versions of AMSAT Cheap Yagis visit www.wa5vjg.com/Reference



Close Up of Driven Element.

Please see the dimensional table on the following page.



Element Dimensions								
145 MHz								
Version:	Ref	DE	D1	D2				
2 Element								
Length	40.5	**						
Spacing	0	7.0						
3 Element								
Length	40.5	**	36.5					
Spacing	0	8.5	19.75					
4 Element								
Length	40.5	**	37.0	32.5				
Spacing	0	8.5	19.0	40.0				
435 MHz								
Version	Ref	DE	D1	D2	D3	D4	D5	D6
3 Element								
Length	13.5	**	12.2					
Spacing	0	2.5	5.5					
4 Element								
Length	13.5	**	12.4	11.5				
Spacing	0	2.5	5.5	11.5				
5 Element								
Length	13.5	**	12.5	12.25	11.75			
Spacing	0	2.5	5.25	12.0	18.5			
6 Element								
Length	13.4	**	12.4	12.0	12.0	11.0		
Spacing	0	2.5	5.5	11.25	17.5	24.0		
8 Element								
Length	13.4	**	12.4	12.0	12.0	12.0	12.0	11.1
Spacing	0	2.5	5.5	11.25	17.5	24.0	30.5	37.75
** Driven element dimensions are from Figure 1								
Ref is the Reflector, DE is the Driven Element and all spacings are measured from the Reflector element.								

Table1. Dimensions for the various Cheap Yagi designs.



AO-7's Frequency Variability as a Proxy for Spacecraft Temperature

by James A. DeYoung, KG4QWC, kg4qwc@arri.net

During 2006 I obtained an Icom IC-910H [1] and SATPC32 [2] to improve my satellite station. SATPC32 allows very easy adjustment of the transmit (Tx) to receive (RX) frequency (loopback) offset to account for any frequency biases. Full Doppler tuning using SATPC32 using the latest spacetrack.org two-line orbital elements was performed for each access through AO-7 (other names are Phase 2B, 7530, and 74089B), which effectively removes the Doppler component from the measurements. Soon after getting SATPC32 configured it was noticed that all the ham linear transponder birds showed different loopback frequency stability behavior. VO-52's loopback frequencies were very stable over time, FO-29 showed some variation as well as larger scatter, while AO-7 was changing at a mildly alarming rate. I began to keep track of the mode (U/V), mode-B, loopback frequency relative adjustment observed for each pass of AO-7, Figure 1. Later, I added monitoring of the 2 m AO-7 beacon frequency, Figure 2.

By December 2006 the AO-7 loopback frequency had stabilized. I noticed that it was about the time the satellite switched to the Mode-A/Mode-B alternating schedule controlled by the onboard 24-hour clock, which is the mode AO-7 enters when in whole orbit full sunlight periods. This fact indicated that the observed loopback frequency changes were likely related to solar illumination. By extension, this fact implied that the loopback frequency variation was related to satellite temperature affecting the AO-7 local-oscillator (LO)

circuit frequency stability.

This paper will show the results of associating measured relative transmit to receive loopback frequency variation as well as the absolute 2-m beacon frequency variation to model satellite temperatures in the AO-7 transponder and beacon LO areas. The most interesting and useful fact is that simply by measuring relative loopback frequency changes or the absolute beacon frequency variation allows their use as a proxy to spacecraft temperature. This relationship should be usable to verify any decoded telemetry since the 2001 discovery that AO-7 was still alive and operating on solar cells. It also should be usable to correlate future satellite operational behavior with model temperature.

The AO-7 Mode-B (U/V) Loopback Frequency

Early on in my AO-7 operating I focused on making standard ham two-way QSOs, but later I shifted focus to maximize tracking the loopback frequency. Later, I added measuring of the beacon frequency as a check and to monitor its stability. For this work my satellite station consisted of a standard Arrow antenna [3] located on a camera tripod located in one of my second floor bedrooms, the IC-910H, SATPC32 and Spectrogram, version 11, software [4]. In addition, I used my trusty analog measurement device, my ears, to make some of the measurements.

The loopback measurements were performed by transmitting and adjusting the ground-station (GS) uplink frequency until the

received downlink audio sounded "normal", see Figure 3. It was estimated that this ear or spectrogram measurement of Tx - Rx was better than +/-50-Hz when care was taken. During noisy or low-elevation passes the "whistle" method was used in combination with the Spectrogram software.

The Icom IC-910H manual [5] specifies a frequency stability of less than +/-3-ppm over the temperature range of -10°C to 60°C. The most precise display frequency resolution is 1-Hz and it was operated at that setting. At the GS uplink frequency of 432.150-MHz +/-3-ppm gives +/-1.3-KHz and at the base GS downlink frequency of 145.950-MHz the frequency stability is +/-0.4-KHz. The implied IC-910H frequency stabilities over the long-term are clearly much better than the Icom specification. This is probably due to the fact that the environment that the IC-910H operates in was stable to a few degrees over the study time. Also the IC-910H was allowed to warm up before making measurements, however this appeared to be not necessary.

AO-7 Thermal Model

Using SCRAP [6] a table of daily average solar percent illumination was generated. Plotting data as it was being accumulated from each operated satellite pass it soon became apparent that indeed there was a high correlation of loopback frequency change with the ratio of sunlight to eclipse during an orbit.

To associate the observed relative loopback and absolute frequency variation to spacecraft average temperatures, a model for the

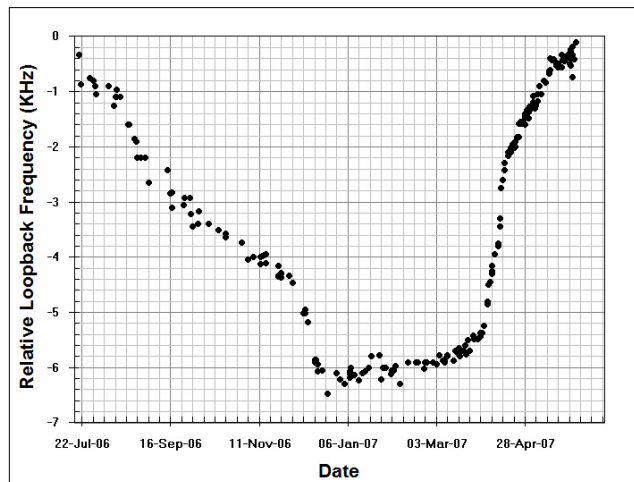


Figure 1. This plot shows the loopback frequency time-series as measured by KG4QWC for AO-7 (mode U/V).

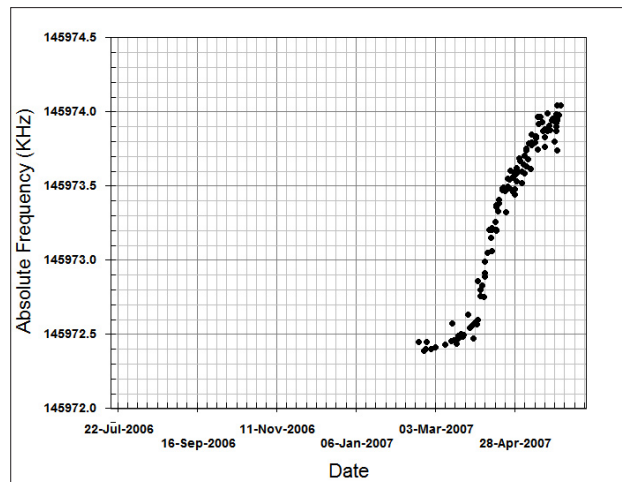


Figure 2. The AO-7 absolute 2-m beacon frequency variation time series as measured by KG4QWC. The x-axis is the same as Figure 1.



spacecraft temperature from the standard thermal equilibrium equations was needed. The ARRL's *Radio Amateur's Satellite Handbook* (RASH) [7] has a chapter on satellite systems that discusses the basics of estimating orbital average satellite internal temperatures using energy input, output and balance equations. A more complete thermal model requires the addition of Earth albedo and IR contributions to the spacecraft thermal budget [8]. The following equation gives the direct solar radiation (P_{ds}) impinging on a spacecraft adjusted for the variation in the Earth – Sun distance between perihelion and aphelion (3.4% variation).

$$P_{ds} = P_0(1/r^2) \quad 1)$$

where P_0 is the direct solar radiation constant (1366-watts/m²) [9] and R is the Earth to Sun distance in astronomical units (AU).

The other component applicable to spacecraft thermal behavior is Earth albedo (A_e) heating by reflected solar energy. The following equation accounts for this component of heating:

$$A_e = \left[\left((1 - ealb) * P_0 \left(\frac{1}{R^2} \right) \right) / 4 \right] * scf \quad 2)$$

where $ealb$ is the average Earth albedo (0.3) and scf is the spacecraft height and shape correction, sometimes called the shape factor or shape modulus correction (0.16) [8] [10]. The total Earth albedo contributed heating variation at the average altitude of AO-7 (1461.8-km) is about 2.8% of the direct solar heating.

Bringing all factors together into the standard spacecraft thermal equation gives:

$$T = 4 \sqrt{\frac{(P_{ds} + A_e) A \alpha \beta}{<A> \sigma e}} \quad 3)$$

where A is the illuminated surface area of

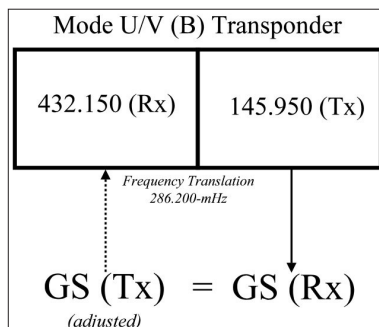


Figure 3. This plot shows the AO-7 loopback measurement system diagram.

AO-7 (1.870-m²) by direct solar rays [7], α is the satellite average surface absorbtivity, β is the fraction of orbit in sunlight, $<A>$ is the effective capture area, i.e. the total surface area of AO-7 (7.770-m²) [7], σ is the Stefan-Boltzmann constant (5.67x10⁻⁸ joules/kelvin⁴m²s, and e is the average surface emissivity.

AO-7 is an eight-sided cylinder with solar cells paving the sides and mostly shiny metal on the end-caps. For system thermal transfer modeling, materials have two basic parameters that are defined; one is the absorbtivity and the other is the emissivity coefficient of the material. The heat transfer characteristics of solar cells and shiny metal are different. Solar-cell absorbtivity and emissivity are both usually around 0.8. The end-caps were bright shiny metal originally. Common values of 0.48 for absorbtivity and 0.08 for emissivity for polished aluminum were selected. To form a spacecraft average I weighted by area for each material type and arrived at overall values of 0.68 for absorbtivity and 0.55 for emissivity. The ratio of the absorbtivity and emissivity is the important relation in equation 3. This equation accounts for nearly all of the frequency variation, which is clearly and logically spacecraft thermally driven.

Evaluating equation 3 over the sunlight to eclipse ratio range of 0.79 to 1.0 per orbit gives model temperatures that agree fairly well with those given in *The AMSAT Newsletter* (1974) [11], which specifies an average temperature at the electronics of 287°K. The RASH [7] gives an observed temperature range of 275°K to 290°K

over the range 80% to 100% illumination and specifies 294°K as the equilibrium temperature of AO-7, presumably in full sunlight. Table 1 gives selected model temperatures using equation 3 (R fixed at 1-AU). The orbit of Earth is slightly eccentric (ranging from 0.9833-AU at perihelion to 1.0167-AU at aphelion during 2006 and 2007. Evaluating equation 3 using extreme values of R gives a maximum model temperature range of 275.8°K to 297.5°K. The resultant model temperatures seem to be very reasonable and no further adjustment was deemed necessary. However, one might expect after nearly 1/3-of-a-century on orbit that the spacecraft surfaces have become somewhat eroded and darkened, thus slightly increasing the spacecraft temperatures from the 1974 and 1975 reported values.

Parameterization of Loopback Frequency to AO-7 Temperature

Entering the data and plotting in a spreadsheet program showed indeed that there was a high correlation of loopback frequency variation with the ratio of sunlight to eclipse during an orbit, Figure 4. Conveniently, equation 3 relates the solar illumination percentage directly to spacecraft temperature, Figure 5. This fact allows the simple parameterization of orbital average solar and earth albedo flux to AO-7 temperature at the LO electronics which generates the transponder reference and translation frequency and the 2-m beacon frequency.

The linear least-squares method was used to fit the measured relative loopback frequency and model temperature (kelvin). The results are shown in Table 2.

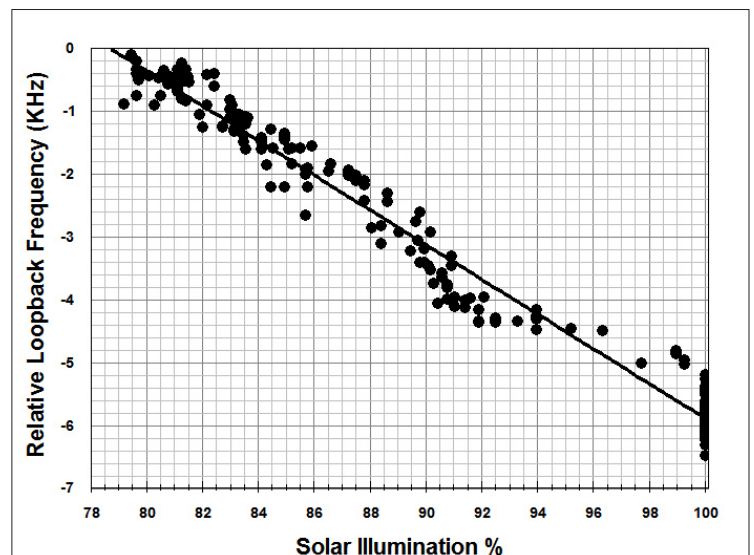


Figure 4. This shows the relationship of average daily solar illumination percentage per orbit with frequency variability.

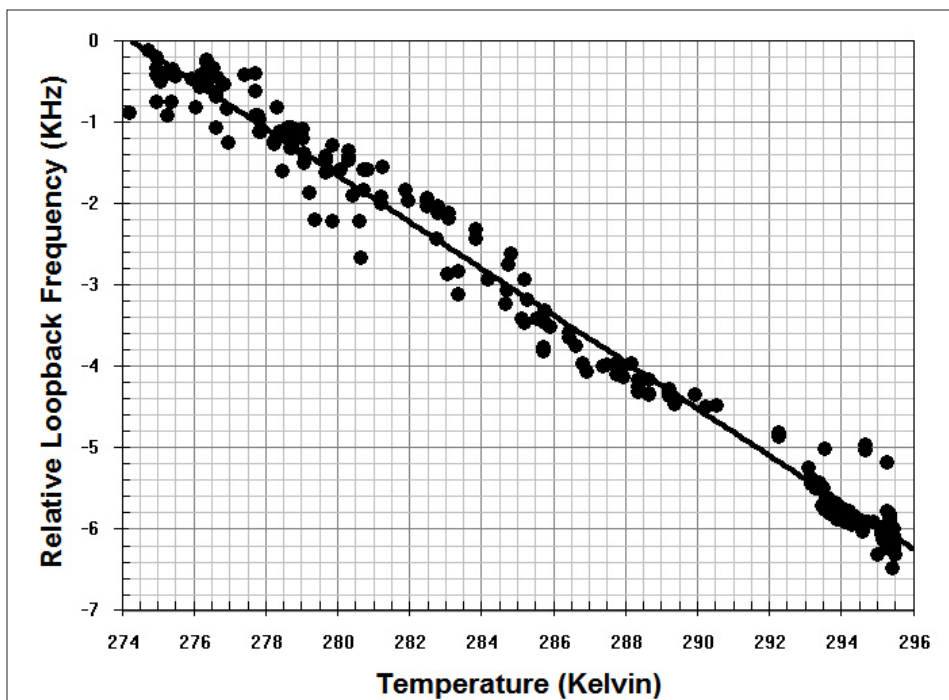


Figure 5. This plot shows the loopback frequency variation versus model temperature for A-7 from equation 3. The model fits very well, however there are some slight indications that more detail needs to be added to the model.

Equation 4 allows recovery of the model temperature from the observed relative loopback frequency measurement

$$RT(Kelvin) = \frac{y-b}{m} \quad 4)$$

where R is the AO-7 model temperature (kelvin), y is the observed relative frequency change (KHz), b is the y-intercept (KHz), and m is the slope (KHz/kelvin).

There was a ramp in the loopback frequency and the 2 m beacon frequency during the 100% illumination period from 2006 December 14 to 2007 April 3, Figures 1 and 2. This ramp was apparently related to the changing distance from the sun during the period. Figure 5 shows the final relationship of loopback frequency variation and AO-7 temperature and it is quite good.

The 2 m Beacon Frequency

The 2 m beacon absolute frequency was determined by adding the Spectrogram measured carrier frequency to the SATPC-32 base frequency. Spectrogram was usually set up with a 60 s spectrum window, 200 to 2700 Hz frequency span and the frequency read off directly and logged. Figure 6 shows the relationship of model temperature and absolute beacon frequency as measured for AO-7. The coefficient is significantly lower than the mode U/V (B) transponder relative change relationship.

The linear least-squares method was used to fit the measured absolute beacon frequency

and model temperature (kelvin). The results are presented in Table 3.

Equation 5 allows recovery of the model temperature from the observed relative loopback frequency measurement

$$AT(Kelvin) = \frac{y-b}{m} \quad 5)$$

where AT is the AO-7 model temperature (kelvin), y is the observed absolute beacon frequency, b is y-intercept, and m is the slope.

The 2 m beacon frequency is clearly having problems, ranging from being fully stable over a pass, to large dispersions, rev-to-rev variability and bounded enveloping. Figure 7 gives three selected audio spectra of a few of the more picturesque variations observed. Usually, the beacon generates gibberish, but rarely the beacon provides decodable telemetry, and extremely rarely do the numbers look correct, i.e. having a value between 649 and 651 for the 6D midrange TLM calibration field. At all times, however, any decoded telemetry should be considered suspect.

Discussion and Conclusions

AO-7 uses passive attitude control using Earth's magnetic field [12] and the radiometer solar propeller effect (RSPE) [13] to prevent any one side of the satellite reaching extreme temperatures. The RSPE was sometimes called the "barbecue rotisserie" technique. Early in AO-7's life, 1975, it reached a stable spin rate in the range of 0.05 to 0.09 revolutions per minute [14]. The results from this paper indicate that the orbital average temperature is still well smoothed out in 2006 and 2007. These easily made ground measurements of loopback frequency and

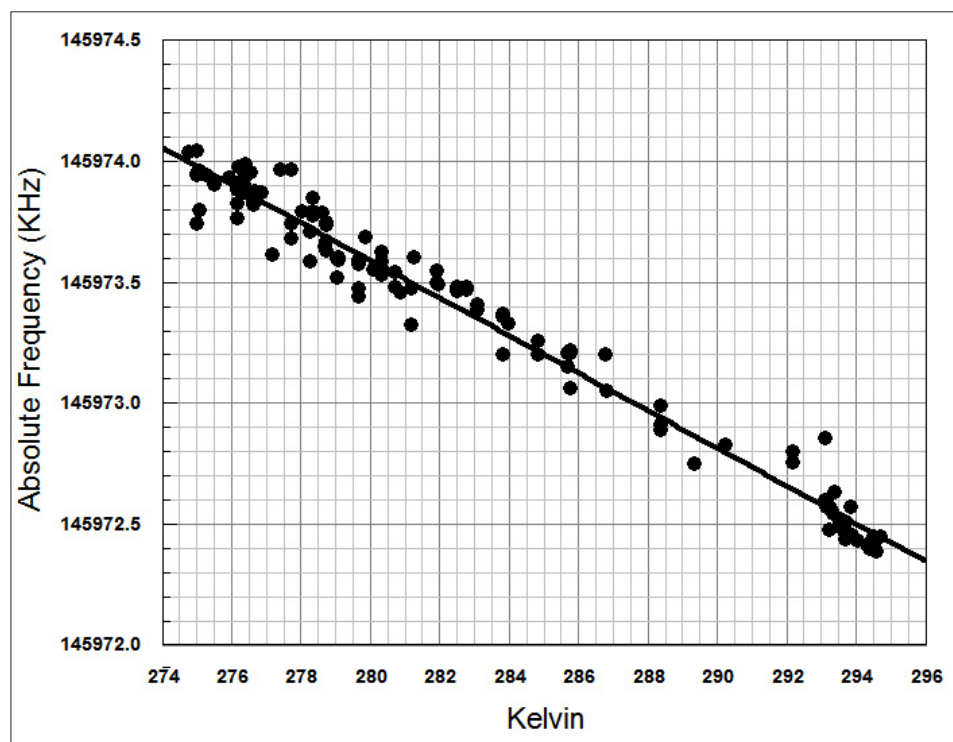


Figure 6. This plot shows the 2-m beacon frequency versus AO-7 model temperature from equation 3. The absolute frequency variation is similar to the loopback relative frequency behavior but with a much smaller amplitude.



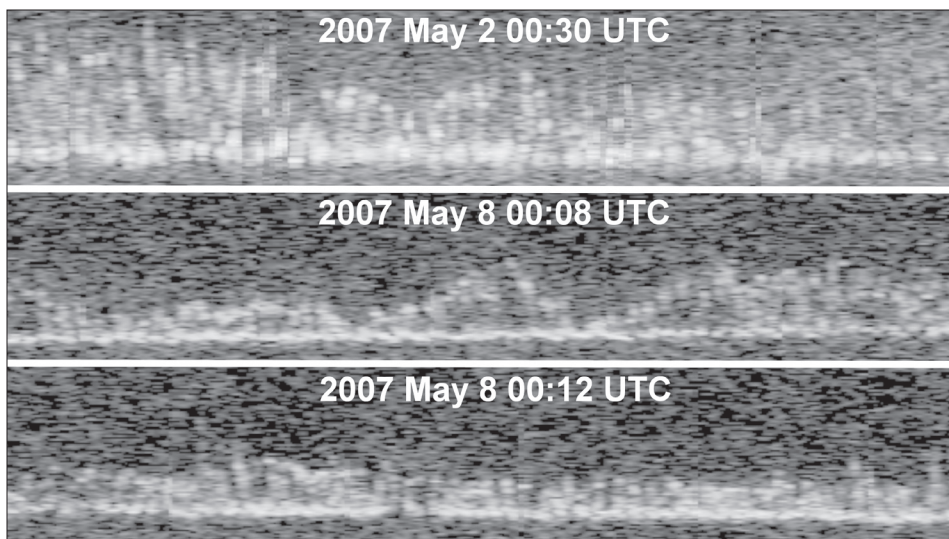


Figure 7. Selected observed frequency variability of the AO-7 2-m beacon. It shows a wide variety of frequency stability behavior from very stable frequency to periodic variable envelopes to steps. Several of the more interesting ones are shown. Each frame width is about 500-Hz in the y-axis and 60-s in the x-axis.

2 m beacon frequency allows recovery of at least one fundamental characteristic of AO-7, its orbital average temperature. This should be useful to watch and trend as AO-7 gets even older.

There is some leftover structure in the temperature against frequency relation that could likely be accounted for in the future as a longer time-series is accumulated. Three possible things to consider for improvement in the future is a more detailed model of the Earth IR contribution to AO-7's temperature, a model of possible Earth terminator effects as AO-7 transitions between eclipse and illumination, and a higher precision spacecraft macro-model. Improvement in the estimates of the material emissivity and absorptivity to account for aging might be possible to add if more specific information of the actual material and its long-term aging characteristics are found. It should be possible to add AO-7 height variation above Earth into equation 3, which currently has an average fixed height included in the scf value. Future antenna improvements will be required at my station to allow an evaluation of Mode A loopback and beacon variability.

AO-7 is an amazing satellite and still holds surprises after nearly one third of a century on orbit.

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Ratio Sunlight/Eclipse	Kelvin	Celsius	Fahrenheit	Ratio Sunlight/Eclipse	Kelvin	Celsius	Fahrenheit
0.79 (79%)	278.1	5.9	42.7	0.90 (90%)	287.3	15.1	59.3
0.80 (80%)	279.0	6.8	44.3	0.91 (91%)	288.1	15.9	60.7
0.81 (81%)	279.8	7.7	45.8	0.92 (92%)	288.9	16.7	62.1
0.82 (82%)	280.7	8.5	47.4	0.93 (93%)	289.7	17.5	63.5
0.83 (83%)	281.5	9.4	48.9	0.94 (94%)	290.4	18.3	64.9
0.84 (84%)	282.4	10.2	50.4	0.95 (95%)	291.2	19.1	66.3
0.85 (85%)	283.2	11.1	51.9	0.96 (96%)	292.0	19.8	67.7
0.86 (86%)	284.1	11.9	53.4	0.97 (97%)	292.7	20.6	69.0
0.87 (87%)	284.9	12.7	54.9	0.98 (98%)	293.5	21.3	70.4
0.88 (88%)	285.7	13.5	56.4	0.99 (99%)	294.2	22.1	71.7
0.89 (89%)	286.5	14.3	57.8	1.00 (100%)	295.0	22.8	73.1

Table 1. The model temperatures from equation 3 expected at 1-AU using the sunlight/eclipse ratio as input.

N	Correlation Coefficient	Std. Err. Est.	m (slope)	b (y-intercept)
205	0.992	0.274	-0.287 (+/- 0.003) KHz/Kelvin	78.8 (+/-0.7) KHz

Table 2. The linear least-squares coefficients and related values allowing recovery of the spacecraft temperature from relative loopback measurements.

N	Correlation Coefficient	Std. Err. Est.	m (slope)	b (y-intercept)
120	0.987	0.084	-0.078 (+/- 0.001) kHz/Kelvin	145995.4 (+/-0.3) kHz

Table 3. The linear least-squares coefficients and related values allowing recovery of the spacecraft temperature from absolute 2-m beacon frequency measurements.



AMSAT at Dayton 2007

by JoAnne Maenpaa, K9JKM, k9jkm@amsat.org

From May 18 through May 20, 2007 AMSAT enjoyed a successful weekend at the Dayton Hamvention showing the Amateur Radio community our special aspect of communications while at the same time demonstrating how satellite techniques are within the reach of interested operators. All of this was presented through the efforts of a team of approximately 25 volunteers. Thanks a million guys and gals!

The AMSAT Booth

Taking up five Hamvention booth spaces AMSAT was able to demonstrate our technology, which gave Amateur Radio operators the opportunity to view:

- A half scale model of the Eagle satellite, plus Eagle power generation system, Ultra cap and NiCd battery
- A prototype of the Eagle 70 cm receiver and Software Defined Transponder software/hardware
- A full scale model of the Echo satellite
- A prototype ARISS antennas for the ISS
- A prototype SuitSat-2 antennas and helmet control box
- Live tracking software interfaced with a working LVB tracker connected between a computer and the Yaesu 5400/5500 rotor controller box driving an az-el rotor system

AMSAT's latest publications and this year's AMSAT Dayton fashions were also available.

New AMSAT publications at Dayton were:

- 2007 *Satellite Frequency Chart*
- 2007 *Getting Started With Amateur Satellites* book
- 2006 *San Francisco Symposium Proceedings*
- *AMSAT Journal* CDs all the way up to 2006 are now available



The AMSAT booth is open for business.

Must-have AMSAT fashions are:

- Black Computer backpacks with AMSAT logo
- White SS Golf shirts with AMSAT logo
- Blue LS heavy tee shirt with AMSAT logo
- Blue baseball cap with AMSAT logo
- AMSAT lanyards with badge clips
- Green medium weight jacket with AMSAT logo and name/callsign

Amateur Radio Satellite technology items for sale included:

- G6LVB computer controlled rotor tracker boards (bare with parts list)
- Digital CD with 1200 - 38k4 test signals, WiSP software and other digital items
- Tracking software: SatPC32, Nova for Windows, SCRAP and IT
- Arrow Antennas

Other good stuff included AMSAT clocks, Eagle decals and patches, ARISS patches and AO-7 QSL cards. These can be ordered via the AMSAT store on the AMSAT Web page.

After our booth was set up on Thursday afternoon prior to the official opening of the Hamvention on Friday, the team enjoyed the annual AMSAT Pizza 'n Suds party at Marion's Piazza. This was a well-attended party with about 50 satellite designers, operators, officers and family members in attendance.

The AMSAT booth also enjoyed a visit from Bill McArthur, KC5ACR, ISS Expedition 12 Commander.

The AMSAT Forum

The AMSAT Forum on Friday featured outstanding list of speakers and topics of interest to all AMSAT members. The forum drew over 100 radio amateurs. **Barry Baines**, WD4ASW, AMSAT-NA Corporate Secretary moderated the session.



Eagle one-half scale model.

The first speaker was **Rick Hambly**, W2GPS, President, AMSAT-NA who gave us the "Summary of AMSAT-NA Activities

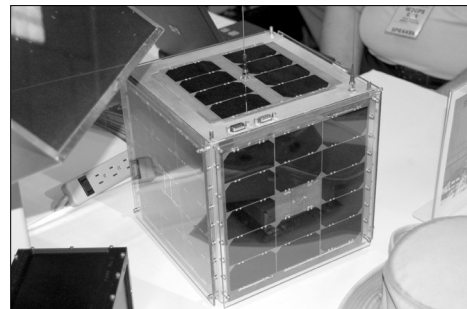


Barry Baines, WD4ASW.

in 2007". Rick reminded everyone that HEO Satellites remain AMSAT's primary vision and mission for the future. In addition to our primary goals, AMSAT will continue assist LEO efforts undertaken by the educational community and other amateur radio groups.

Rick continued with a list of achievements for 2006 including the following:

- AO-51 has now passed 2 years of continuous operation. Software upgrades and testing are now in progress to further improve this satellite and the operator's experience.
- SuitSat-1 captured the world's attention and helped promote Amateur Radio.
- SuitSat-2 development is currently underway and will feature an SDR transponder, SSTV cameras, and experimental packages.
- AMSAT-NA support for AMSAT-DL's P3E provides funding, and staffing for design, testing and integration.
- Eagle satellite development is ongoing



AO-51 model.

concurrently with P3E and the satellites will both share common modules and software.

- AMSAT's education outreach provides mentoring to student's who are designing, building, and launching satellites. AMSAT continues to work with the ARISS team developing lesson plans for school contacts.
- The AMSAT Lab in Maryland was opened. The clean room equipment is currently being installed.

Bob McGwier, N4HY, AMSAT VP-Engineering, spoke on behalf of AMSAT-DL's Peter Guelzow, DB2OS, to describe progress for their Phase 3-Express (P3E) satellite. In addition to providing AO-40 class transponder operations, P3E will



Bob McGwier, N4HY.

provide a test bed for proof-of-concept of critical systems needed for the planned P5A mission to Mars. P3E is being built in an AO-13 space frame but will feature new electronics and software. It will also include the same Software Defined Transponder, Internal Housekeeping Computer, and CAN-DO control bus modules that are planned for AMSAT Eagle. Launch opportunities are currently being explored.

Bob then continued with an Eagle Status Update. His slides showed how the Software Defined Transponder will be integrated in



Eagle. He discussed the exceptional increase in radio performance to be introduced via the Software Defined Transponder technology. This included received and demodulated high fidelity audio clips recorded during AMSAT's SDR testing. Details were also discussed about the HELAPS RF power amplifier, phased array antennas, and the breakthrough with getting the first 70 cm receiver debugged and working. This receiver is now ready to start acceptance and performance testing. Bob described the features of the Advanced Communication Package. More details of Eagle will continue to be published in future issues of *The AMSAT Journal* and on our EaglePedia Web site.

The next speaker was **Gould Smith**, WA4SXM, AO-51 command station, who told us about "AMSAT-NA Satellite Operations and AO-51 Update." Gould described the work of the AO-51 Operations Group who are currently writing and testing new software to be uploaded into AO-51. He also gave everyone an overview of an AO-51 command station.

Frank Bauer, KA3HDO, AMSAT-NA Director-Human Space Flight, gave an impressive presentation of "ARISS and Future SuitSat Missions." Frank was able to include mission audio clips, SuitSat audio clips, and NASA video of SuitSat.

Copies of Frank's presentation materials are available on the AMSAT Web at:

<http://www.amsat.org/amsat/ariss/Presentations/Dayton%20Hamvention>.

According to records, ARISS school contacts from the International Space Station have reached over 15,000 students. Also, every ISS crew between Expedition 14, now on orbit, through Expedition 19 in 2009 will have a licensed Amateur Radio operator aboard.

SuitSat-2 is currently under development. Work continues as the team awaits official approval by the various space agencies for a planned deployment in February 2008. The SuitSat-2 project includes these features:

- Expanded education outreach with prepared lesson plans. This will also include student DVDs and other flight items
- Software Defined Transponder capable of supporting SSB, CW, FM voice, SSTV, and CW IDer. An uplink passband at approximately 145.9 MHz and



AMSAT President, Rick Hamby, W2GPS.

downlink passband at approximately 437.6 MHz is being proposed.

- SSTV support for up to 4 cameras.
- Solar panels in addition to battery power to support the radio payload plus additional sensors, and 4 experimental packages.

Lou McFadin, W5DID demonstrated a prototype SuitSat-2 helmet mounted antenna for 2M and 70cm. He also showed the proven safety interlock control box used by the astronauts to activate SuitSat.

Howard Long, G6LVB continued the ARISS discussion by showing the new Amateur Radio equipment which will be included in ESA's Columbus Laboratory module to be attached to the ISS in early 2008. This will feature a linear transponder with L-band uplink and S-band downlink.

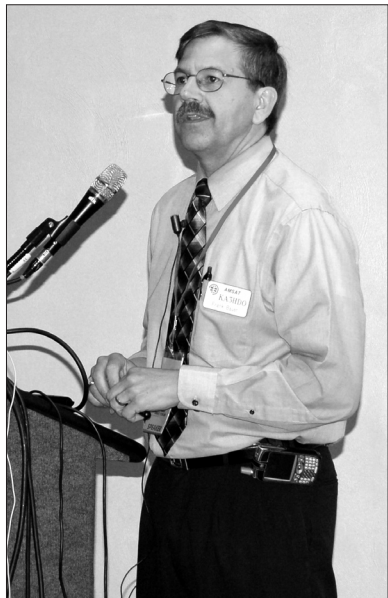
Live Satellite Demos

Joe Prokop, KC8RAN reported, "The satellite demonstrations at Dayton this year



Gould Smith, WA4SXM.

were a success. The goal was to show that it's not very hard to get into the satellites with relatively simple and inexpensive equipment." Here is Joe's story of the satellite demonstrations ... Keith Pugh, W5IU, along with Roger Ley, WA9PZL, and Joe Prokop, KC8RAN, conducted the demonstrations in the area outside of the Ballarena entrance. Using a pair of FT-817's (one for uplink and one for downlink)



WA4SWJ

Frank Bauer, KA3HDO.

allowed for both FM and SSB contacts. The antennas used were a homebrew array composed of a 2 meter and 70 cm “cheap yagis” built with welding rods as driven elements and aluminum wire for directors and reflectors. For the FM satellites, Keith used an Arrow antenna and one of the FT-817’s running half duplex, while Joe used the 70cm Yagi from the array to monitor the downlink on a W32A in another corner of the demo area to allow more people to hear the signal for the bird.

Early on there were some difficulties with one of the FT-817’s and we missed a pass on AO-7. After some productive scavenging by Keith, we were in business for the next opportunity. Overall we had about a dozen contacts through the demonstrations on Friday and Saturday. The contacts ranged from California to Ottawa, Canada and many stations in the East and Midwest paths of the birds. Keith even conducted a cross mode contact with a CW station on one of the linear satellites.

Many questions were asked about the plans and methods for the antennas, and many pictures were taken of the array by the audience and other passers-by. The array was clearly the star of the show. During the time between passes, Keith, Roger and Joe answered many questions about satellite operation. The story of the re-birth of AO-7, originally launched in 1974 was also told many times during the discussions.

The biggest “wow” factor came on Saturday when Keith joined a roundtable on VO-52. The other stations in the roundtable complimented Keith on the strong signal to the bird as we approached LOS on Saturday.

Not bad for 5 watts into brass welding rods, aluminum wire, some wood and PVC pipes!

Numerous comments were received back at the booth about how well the demonstrations were presented, how remarkably well

Thanks For Everyone’s Help!

Gould Smith, WA4SXM, Director of Field Operations, who lead the Dayton Booth team summarized, “Many thanks to the volunteers who made the AMSAT booth at Dayton such a success. From setup, operation,



N4HY

The joint AMSAT/TAPR Banquet. What a scene!

the signals were received, and how the individual now better understood satellite operating having seen it in person.

AMSAT/TAPR Friday Banquet

The joint AMSAT and TAPR “Under the Wings” banquet held in the Wright-Patterson Air Force Museum was considered a major success. In addition to the meal on Friday evening over 300 participants were able to also enjoy touring the museum displays. We received many enthusiastic compliments at the booth the next day for this event.

demonstration, explanation, salesmanship to tear down we were blessed to have such a dedicated group of people make it happen so well. The banquet was extraordinary. This was truly a great weekend experience.” So this wraps up a great year for AMSAT at the 2007 Dayton Hamvention. We’re looking forward to seeing you in Dayton in 2008!



N4HY

Pizza and Suds sure looks like fun!



the Internet by AMSAT-NA volunteers. This prototype unit is now working and awaits software work being done in both the US and Germany.

A critical issue is the ongoing relationship between AMSAT-NA and our international partners as regards ITAR, the US regulation that defines the rules relating to export of satellite technology and services from the US. This is a highly technical legal issue but we are getting excellent professional help. After six difficult months of effort I can tell you that AMSAT is on track to have this issue resolved. I have, for the third time, submitted our registration papers to the US

possible solutions.

There have been further developments regarding the design of steered antenna arrays for S2 and C-bands to support the Advanced Communications Payload. Based on ideas from Tom Clark, K3IO, we think we are ready to prototype a test of the array phase control mechanism and some parts have been ordered to do that.

There is a proposal to have another design meeting this summer on the Advanced Communications Protocol (ACP) payload. I don't know if we will have this meeting in San Diego, but I expect that we will ramp up the level of activity on this project not that

We have selected the components that will comprise a satellite ground station at the lab. AMSAT is providing the radios and a computer. Hawk is providing much of the rest, including a 60-foot tower, UHF and VHF Yagi antennas, an az-el rotor, coax cable and control cable. Hawk is negotiating with the landlord and the building inspector about the tower installation.

Hawk is getting some 8-week summer interns soon and is assigning one of them to AMSAT related work including setting up a computer, documenting its operation and working on the clean room.

The office space is now complete and in use. The dry wall is up in the lab area and the machine shop. Painting of these areas will be done by the end of July. At that point we will be able to use these areas, probably including the clean room.

We are still looking for a screen room for the lab. Our first potential donor fell through but another donor has surfaced and there is a good chance that we will have a modest 8x8 foot clean room before the summer is over.

Our goal is to have the tower erected and the clean room in operation by end of the summer. This may be a bit optimistic but we are hopeful.

73,
Richard M. Hambly, W2GPS
AMSAT President

References

- [1] http://en.wikipedia.org/wiki/Marketing_Section_1,_Introduction



Installing some air handlers in the new AMSAT lab.

State Department and I expect that they will be approved this time. We have begun drafting Technical Assistance Agreements (TAAs) that will define our relationships with AMSAT-UK, AMSAT-DL and possibly others. Once complete I hope we will be able to concentrating all our efforts on the development of satellites, both here and abroad.

Eagle Satellite

The UHF receiver design has been the source of significant activity lately. A prototype receiver has been designed and integrated with a CAN-Do interface module. As far as I know, this is the first time that CAN-Do has been used on a sensitive RF module. There are the predictable noise problems due to the small switching supply on CAN-Do. Juan Rivera, WA6HTP, has been doing a great job of characterizing the problem and exploring

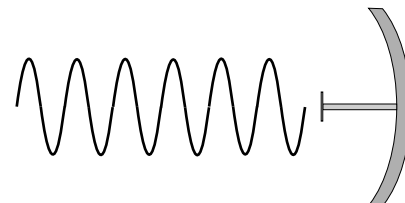
the phased array antenna design is moving forward.

AMSAT Lab

The new AMSAT Lab in Pocomoke City, MD continues to move towards operational status. The 20'x20' clean room with its massive air handlers has been cleaned, painted and assembled. We have quotes for new air filters, walls and skirts at a cost of about \$15,000 and will soon have them on order.

Through a joint AMSAT and Hawk Space Institute effort, a one-half scale Eagle mockup was built in time to be displayed at Space Day at the Smithsonian Air and Space Museum in May and two weeks later at the AMSAT booth at the Dayton Hamvention. Thanks go to Bob Davis KF4KSS and his team of volunteers for a job well done.





Jerry Ervine, KC5YRE, sent some photos of a satellite presentation he made to the Webfoot ARC located in the Rio Grande Valley of Texas in February 2007 during a meeting of the club. Jerry is shown at left in this picture demonstrating the use of a handheld satellite antenna.



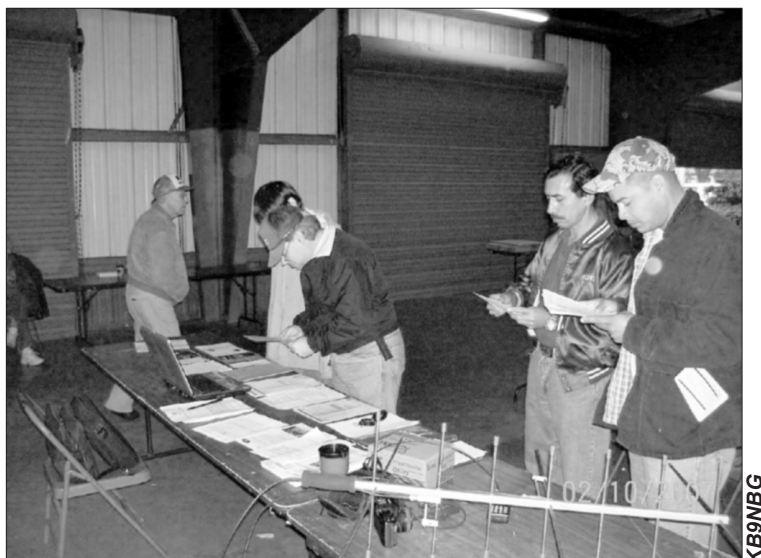
WU8H

Jerry also made presentations at the Webfoot ARC hamfest in McAllen, Texas in February. Jerry says the groups at both events were very receptive and learned a lot about satellite operations and AMSAT.



KB9NBG

Interested hamfest attendees obtain information on satellites and on AMSAT.



KB9NBG

Jerry can be reached at KC5YRE@amsat.org.





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